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**AN INVESTIGATION OF TOMATO HANDLING PRACTICES AND ITS
POSTHARVEST LOSSES ALONG SUPPLY CHAIN: THE CASE OF ADEA WEREDA,
EAST SHOA, ETHIOPIA.**

**BY
BOGALE TESHAYE**

**A THESIS SUBMITTED TO SCHOOL GRADUATE STUDIES
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF DEGREE
OF MASTER OF SCIENCE (M.SC) IN FOOD SECURITY AND DEVELOPMENT
STUDIES.**

AUGUST, 2019

ADDIS ABABA, ETHIOPIA

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DEVELOPMENT STUDIES.**

**AUGUST, 2019
ADDIS ABABA, ETHIOPIA**

DECLARATION

This thesis is my original work and has not been presented for MA/MSc degree in any other University and that all the sources and materials used for the thesis have been properly acknowledged.

Declared By: Bogale Tesfaye Signature: _____ Date: _____

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.

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As member of the Examiner Board of the Thesis Defense, we certify that we have read and evaluated the thesis studied by Bogale Tesfaye entitled “An Investigation of Tomato Handling Practices and Its Postharvest Losses along Supply Chain: The Case of Adea *Wereda*, East Shoa, Ethiopia” and recommended that it is acceptable as thesis required for the degree of Master of Science Degree in Food Security and Development Studies.

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Final approval and acceptance of this thesis is depending up on the candidate’s submission of the final copy of the thesis, incorporating all the comments by Examining Board, to the Council of Graduate Studies through the Center Academic Committee of the Center.

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List of Abbreviation and Acronym

AVRDC	Asian Vegetable Research Development Center
CSA	Central Statistics Authority
EIA	Ethiopian Institute of Agricultural
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Kg	Kilogram
Ha	Hectare
MoA	Ministry of Agriculture
MOFAED	Ministry of Finance and Economic development
PHL	Postharvest Losses
PHM	Postharvest Management
Qt	Quintal

Abstract

Tomato has significant economic importance in Ethiopia. The study was conducted in 2019 in two kebeles (Godino and Denkaka) located in East Shewa Zone of Oromia National Regional State, Ethiopia, located southeast of Addis Ababa. The Objective of the study is to examine the handling practices of tomato along supply chain, to identify the constraints of Postharvest losses of tomatoes along supply chain and to estimate the value of tomato losses at different stage the in the study area. Purposive and Multiple stage sampling technique were employed to sample representative farmers and traders' respondents (N=222). Data was gathered through questionnaire, observations, key informant interview and focus group discussion. Data were analyzed using descriptive and tobit stata. Chi²(0.89) the age, marital status, level of education, washing and cleaning, family size, experience in farming, mode of transportation, sorting and grading, loading and unloading, training, packing by carton and marketing information highly positively significant affect tomato post harvest management practices at farm level at p-value 0.000 or 99%. The total postharvest loss of tomato was estimated to be about 16.82% at the farm level. It can be concluded that significant amount of tomato loss occurred in the supply chain which is mainly attributed to poor postharvest handling practices. Based on the findings of this study it is hereby recommended that postharvest technology should support tomato farmers as well tomato traders for this reason, both sector agricultural and trade an industry work in collaborate to provide training on post-harvest handling practices in order to increase farmer' and traders' incomes and minimize tomatoes wastages in the study area.

Keywords: *Tomato, Postharvest handling practices, Post-harvest losses, farmers, Traders,*

1. INTRODUCTION

1.1 Background of the Study

Agricultural products such as fruits and vegetables can contribute to increased food security as well as better nutrition intake which could lead to economic development (Weinberger and Lumpkin, 2007). China is the largest tomato producer, accounting for about one quarter of the global output, followed by United States and India. Tomato ranks next to potato and sweet potato in respect of vegetable production in the world (FAO, 2006). Food and Agriculture Organization of the United Nations (FAO, 2011) shows that one-third of food produced for human consumption is lost globally, which is equivalent to about 1.3 billion tons per year. Increasing the food availability is therefore not only increasing the productivity in agriculture, there is also a need to lower the losses (Kader, 2005).

Tomatoes contribute to a healthy, well-balanced diet. Tomato is rich in minerals, vitamins, essential amino acids, sugars and dietary fibers (Ayandiji et al., 2011). Tomato contains much vitamin B and C, iron and phosphorus. Tomato fruits are important for food industry as they serve as raw material for production of value added products that can be processed into purées, juices and ketchup salads or cooked in sauces, soup and meat or fish dishes, Canned and dried tomatoes are economically important processed products (Babalola et al., 2010). Yellow tomatoes have higher vitamin A content than red tomatoes, but red tomatoes contain lycopene, an antioxidant that may contribute to protection against carcinogenic substances (Naika *et al.*, 2005).

The post-harvest and marketing system is a chain of interconnected activities from the time of harvest to the delivery of the food to the consumer, often referred to as “farm to fork” (Zorya *et al.*, 2011). Postharvest losses aggravate hunger by causing less food to be available for consumption (FAO, 2009). According to GIZ (2013) investing in Post-harvest losses reduction is a quick way to enhance food security without increasing production. Post-harvest losses can be caused by mechanical damage and injury, physiological processes, poor handling, lack of processing, inadequate packaging, poor logistics and sub-optimal storage conditions (Chakraverty et al., 2003).

A large amount of food and products are not reaching the consumer particularly due to post-harvest losses (World Bank, 2010) during harvesting, handling, transporting, storage, processing, packaging and distribution. Handling and processing of the food are of high importance in order to ensure food-safety (Kader, 2003). Post-harvest loss leads to an inadequate food intake and it could be manifested by seed loss, monetary loss, food loss and loss of reputation which in turn affect marketing (FAO and World Bank, 2010). According to Kader (2005), Post-harvest losses (PHL) occur in horticultural produces both quantitative and qualitative which starts from harvest until consumption. PHL is a measurable quantitative and qualitative loss of a product at any moment during the post-harvest chain and includes the change in the availability, edibility, wholesomeness or quality of the food that prevents its consumption (Adeoye, 2009). Quality loss is the result of improper handling and transportation of marketable of produce (Kumar *et al.*, 2015). The effect of poor post-harvest practices increases production wastages and lowers marketing efficiency. Poor demand forecasting, inefficient inventory control systems (Kaipia *et al.*, 2013), and lack of supply chain coordination. Hence, it must be harvested at the right time because overripe tomato is more susceptible to physical injury than ripe and pink ones (Ullah, 2009).

Tomatoes in Ethiopia are produced mainly in the Northern and Central Rift Valley areas. The production of fruits and vegetables in Ethiopia is normally scattered and carryout by a great number of small farm holders and transported long distance to reach central markets. Oromia region contributes the lion's share of Ethiopia's total tomato production (56, 279 MT or 68%) with the remaining production coming from Meki (9%), Tigray (5%) and Somali region (4%). It is estimated that more than 254, 000 farmers are engaged in tomato farming (Tefera and Tefera, 2013). From the highly perishable 0.5 million tons are tropical fruits including Tomato, Banana, Mango, Papaya, Avocado, Guava and Pinapple (CSA, 2012). From a total of 39.7 million tonnes of total crops produced in Ethiopia, 23.1 million tonnes are not highly perishable whereas 6.6 million tonnes are highly perishable (CSA, 2012). On the other hand these fruits have high productivity; Tomato (29.5 Q/ha), Papaya (170.5 Q/ha), Avocado (81.0 Q/ha), Banana (81.2 Q/ha), Mango (90.3 Q/ha) as compared to national average crop productivity (20.0 Q/ha) (CSA, 2012).

1.2. Statement of the Problem

Post-harvest losses are multifarious and can include poor pre-harvest practices, inappropriate handling, storage and transport logistics. Postharvest loss of Vegetables in Ethiopia could be as high as 40% (Bezabih Emanu et al., 2017). Postharvest losses in 2012 for Teff were estimated at 12.3%, for sorghum at 11.6%, for wheat at 9.9 %, for maize at 16.8% and pulses at 19.6%. The recent study conducted by Addis Ababa University and the Swiss Agency for Development and Cooperation (SDC) in two communities in the East Gojam zone of the Amhara National Regional State showed that postharvest losses can be as high as 30% to 50% (Dubale Befikadu, 2018).

Postharvest handling of tomato in East African Countries such as Ethiopia, 1.7% losses at in field, by reason like Insects, birds, disease, mechanical damage 10% at transportation Retail, Over-ripening, disease, mechanical damage 14.5% Wholesale 9.6% Over-ripening, disease, mechanical damage. (Journal of post-harvest handling of tomato in Africa, National Institute of Horticultural and Herbal Science, 2016). 45.9% was the total postharvest loss on banana in Ethiopia, which about 15.7% was incurred at farm, 22.1% at wholesaler and 8.1% at retailer levels. The postharvest loss of banana (1.5 %, 1.2% and 4.5 %); tomato (2.5 %, 2.5% and 5.9 %); mango (1.6 %, 1 % and 3.7 %) and papaya (1.5 %, 1% and 3.3%) at farmer's level, transportation and storage respectively and the major causes are pre harvest infection and injury (Seid et al 2013, cited in Muluken et al., 2017).

In the study area handling practice of tomato and Postharvest loss along supply chain starts at the farm level and cross up to marketing places may be associated to factors, such as lack of appropriate handling materials, lack of information, lack of storage facilities and inadequate market access to immediately sell their product, poor handling, and marketing systems. Most of the studies undertaken were estimated the percentage of tomato post-harvest losses. Therefore, the present study was conducted to investigation of handling practices and postharvest quantify losses and cause of Tomato along at Adea wereda in East Shoa Oromia regional state.

1.3. Objectives of the study

1.3.1 General Objective

To investigate Tomato's Handling Practices and Its post-harvest losses along its supply chain.

1.3.2 Specific Objectives

The specific objectives of the thesis include:

- To examine the handling practices of Tomato along its supply chain.
- To estimate the amount of post-harvest losses of tomatoes along the supply chain.
- To estimate the value of tomato losses at different stages.

1.4. Research questions

- What are the handling practices of tomatoes along supply chain and how do they contribute to loss?
- How to estimate the quantity of tomato losses at farmers and traders level?
- What are the post-harvest technologies that minimizing tomato post-harvest losses?

1.5. Significance of the Study

The main significance of the study was to improve post harvesting practices and reduce post-harvest losses along supply starting from producers up to retailers. The result of this study may be useful to minimizing Tomato losses by applying better technology that prolongs the shelf life of tomato product. The role postharvest management to food security such as prolongs the shelf life of tomato enables improvement of on farm storage, ripening post-harvest handling practices of tomato growers and contributing toward improving tomato post-harvest handling practices of market vendor contributing to extending. Additionally, the study has importance for policy makers to formulate tomato handling area and post-harvest management (PHM) programs and guidelines for interventions that would improve efficiency of the Tomato marketing system. It also provides a holistic picture of existing challenges, opportunities and entry points in the tomato

fruits value chain. Furthermore, this research might help the researchers to gain baseline how to conduct research and the potential users (i.e. producers, traders and postharvest handlers) will find it easier to streamline their activities along the supply chain. The finding of this study is a useful input for Adea *Wereda* of Agriculture development office to minimizing postharvest losses of tomato along its supply chain.

1.6. Scope of the Study

The study was carried out in one wereda, namely Adea *wereda* of East Shoa Zone. Geographic area coverage of Adea *wereda* which is located in East Shoa Zone, Oromia with specific focus on tomato handling practice and postharvest losses along its supply chain from Godino and Denkaka to Adea *wereda* market centre (Bishoftu town). Basically, identifying the roles local tomato collectors, minimizing Tomato Postharvest losses, use appropriate technology among the chain actors and identification of cause of Post-harvest losses are core of the research. Methodologically, the study was descriptive and expository study. In carrying out research, to make it manageable and focus it is important to delimit its scope.

1.7. Limitation of the Study

Methodological limitations for handling practices and postharvest losses of tomato needs instrument uses for qualitative data collection, but due to time and budget constraints the questionnaire and focus group discussion was employed. Conceptually, the study limitation does not incorporate the enabling environments to assess the value chain and it also does not consider the marketable surplus of the fruit in the study area. The geographical limitation of the study was emphasis for only two *kebeles* of from the Adea *wereda*.

1.8. Organization of Thesis

This thesis is organized into five chapters. Chapter one deals with introductory part of the research includes the background, statement of the problem, objectives, research questions, scope and limitation of the study and significance of the study. Following this, Chapter two presents review of literatures that provides broader view on conceptual and theoretical perspectives of tomato post-harvest handling practices related concepts, theoretical and empirical studies of tomato post-harvest losses. Chapter three describes the study area and research

methods and chapter four devoted to the presentation and discussion of the major findings of the study. The final chapter concludes the findings of the study with certain policy recommendations and strategic considerations.

2. RELATED LITERATURE REVIEWS

2.1. Theoretical literature review

Tomato is originated from South America and was introduced to Europe in the 16th Century and later to East Africa by colonial settlers in the early 1900(Wamache,2005). It is between 1935 and 1940 that Tomato was introduced into Ethiopian agriculture. World tomato production in 2001 was about 105 million tons of fresh fruit from an estimated 3.9 million ha. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily. The national average of tomato seed yield under farmers conditions in Ethiopia is also very low, estimated at about 1.2 quintals /ha (Lemma, 2003). Seeds are one of the least expensive but most important factors influencing yield potential. Crop seeds contain all the genetic information to determine yield potential, adaptation to environmental conditions, and resistance to insect pest and disease. Increasing agricultural production through the use of high quality seed, among other agricultural inputs, has become essential for providing enough food for rising number of people in the world. Seed produced under controlled condition is likely to be higher yielding and is less likely to harbor pathogen than locally produced seeds.

Tomato fruits should be harvested at mature green state for long distance marketing and full ripen stage for fresh consumption in order to reduce postharvest losses (Moneruzzaman et al., 2009). The variety of tomato cultivated affects the level of postharvest losses experienced by farmers as different varieties have different characteristics such as firmness, disease resistance, among others, which impact on postharvest losses. Orzolek et al.,(2006) recommended that tomato producers should harvest mature fruits in the morning when the temperature is cool to reduce losses. Food losses can either be the result of a direct quantitative loss or arise indirectly due to qualitative loss.(Kader,2002).Postharvest loss is one of the problems facing the agricultural sector in the developing countries.

Improper harvesting and postharvest handling practices result in loss due to spoilage of the produce before reaching to consumers along with the loss in quality of the produce such as deterioration in appearance, taste and nutritional value. The high perishable nature of fruit, lack of storage facilities, mechanical injuries due to improper handling, packaging, transportation, and microbial infection are the major reasons for postharvest loss in fruits. Higher postharvest losses

not only reduce the availability of fruits but also result in increase in per unit prices of the produce and thus limit the accessibility by the majority of community segments (Devkota et al., 2014).

2.1.1 Concept of Post-harvest handling practices

Post-harvest system, according to Grolleaud (2004), encompasses a sequence of activities and operations that can be divided into two groups. The first group contains technical activities which include harvesting, field drying, threshing, cleaning, additional drying, storage, processing; while the second group, economic activities include transporting, marketing, quality control, nutrition, extension, information and communication, administration and management. Post-harvest begins when the process of collecting or separating food of edible quality from its site of immediate production has been completed. Actually, post-harvest begins at the moment of separation of the edible commodity from the plant that produced it by a deliberate human act with the intention of starting it on its way to the table. The post-harvest period ends when the food comes into the possession of the final consumer. Within the food system there is a stage of preparation for production (pre-production); a period of production; a time for harvest; occasions for transportation; stages where assembly, packaging or selection occur; several periods of short or long term storage; and stage where food is distributed to the consumers. Grolleaud(2004) mentioned that the list the following as the main elements of the post-harvest system: harvesting, pre-harvest drying, transport, post-harvest drying, threshing, storage, processing and marketing. According to him, the time of harvesting is determined by the degree of maturity. With cereals and pulses, a distinction should be made between maturity of stalks (straw), ears or seedpods and seeds, for all these affect successive operations, particularly storage and preservation.

Usman(2000) defined loss as the reduction in the amount of food (in quality and quantity) available for consumption. Grolleaud (2004) shared the same view that food loss is the total modification or decrease of food quantity or quality which makes it unfit for human consumption. Quantitative loss is a loss in terms of physical substance, meaning a reduction in weight and volume and can be assessed and measured. Qualitative loss, however, is concerned particularly with the food and reproductive value of products and requires a different kind of evaluation. Apart from these, other types of losses are weight loss, quality loss, food loss, seed viability loss and commercial loss. In the same vein,(Kader, 2003) mentioned that the following as the

categories of losses that are generally recognized weight loss, quality loss, nutritional loss, loss of seed viability, and commercial loss. Weight loss is the reduction in weight of a commodity is usually as a result of reduced moisture content. Quality loss is noticed when the quality of a produce is assessed in different ways according to those factors considered important by the consumers or traders. Generally, quality is assessed by and products graded on the basis of appearance: shape, size etc., the amount of foreign material (which may include insects and insect fragments); and damage including insect damage. The higher the standard set by the consumer, the greater will be the potential for loss (Kader, 2003). Loss of seed viability relates to loss in seed germination which is important for its effect on future food supplies. Insects that selectively attack the germ will cause greater loss in germination than those feeding on the endosperm (Kader, 2003).

According to Kereth et al.,(2013)biological(internal)causes of fruit and vegetable quality deterioration include respiration rate, ethylene production and action, rates of compositional changes (associated with color, texture, flavor, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological break down (Kader,2005).These intrinsic characteristics depend with the product. Exposure to stressful conditions such as high temperature, air, bruising among others creates a suitable environment for the produce to deteriorate. Mechanical injuries (such as bruising, surface abrasions and cuts) can accelerate loss of water and vitamin C resulting in increased susceptibility to decay-causing pathogens (Kader, 2004). It is very important to note that management of harvesting operations, whether manual or mechanical, can have a major impact on the quality of harvested fruits and vegetables. Huge postharvest losses are incurred in fresh produce due to the physiological form of fruits and vegetables; they deteriorate easily in transit and storage, especially under conditions of high temperature and humidity (Mbuk et al., 2011).

2.2. Empirical literature of tomato post-harvest losses

Developed world (North America, Oceania, and Europe) and the industrialized Asian nations such as China, Japan, and South Korea share about 56% of food loss and waste occurs from total loss whereas the developing world accounts for 44% of the loss (FAO, 2011). In the developed countries loss occurs more at the consumption level, however, in developing countries, it occurs more during production and handling and storage (Lipinski et al., 2013). In Kenya Tomato production accounts from 14 % of the total vegetable production and 6.72 % of the total horticultural crops. Agriculture accounts for 42.9% of gross domestic product (GDP) of the country (MoFED, 2014) and it contributes to nearly 80% of export earnings. However, many of the developing countries peoples are highly dependent on root and tuber crops as a source of food, nutrition and cash income. Postharvest losses are the major obstacles in achieving sustainable fresh produce chains and have repercussions for food security, especially in developing countries where approximately up to 40% of the harvested fruit and vegetables end up not being acceptable for human consumption (Hodges *et al.*, 2010; Gustavsson *et al.*, 2011). Losses of tomato produce can occur at all stages throughout the marketing and distribution such as storage, packaging, transportation, processing and marketing(Weinberger et al., 2008; Kitinoja, 2010).Post-harvest losses(PHL) in fresh produce chains in Sub-Saharan Africa ranges from 30 to 50% Kitinoja *et al.*, (2011). Main causes of significant post-harvest losses in the early stage of the supply chain in developing countries are financial and structural limitations in harvest techniques, storage, and transport infrastructures, combined with climatic conditions favorable to food spoilage (FAO, 2013).

Postharvest losses can occur at any stage in the production and marketing chain. It is estimated that these losses due to inadequate postharvest handling, transportation and storage in fruits and vegetables is relatively higher, 20-50% in developing countries when compared to 5-25% in developed countries (Kader, 2005). When looking at the distribution of the loss and waste, there is significant variation between developed and developing regions. Relatively there are high food losses of fresh root and tubers in developing countries early in the supply chain (FAO, 2011). As a result wastage of starchy roots appears in the top because of high wastage volumes in the agricultural and post-harvest phases (FAO, 2013). One reason for this high loss in these countries

is the perishable nature of the crops which make them easily damaged during harvesting and post-harvest activities especially in the warm and humid climates (FAO, 2011).

In Nigeria, tomato accounts for about 18% of the average daily consumption of vegetables (Babalola et al., 2010). Poor post-harvest handling as a result of lack of storage facilities, good road network, good marketing channel amongst others, brings to the fore the need for efficient harvesting, handling, transportation and marketing techniques to curb postharvest losses in tomato production. This tends to have a multiplying effect of rot on the healthy fruits. Also, fruits and vegetables which include tomatoes produced in rural areas are hardly taken to the market either due to lack of access to nearby markets or inadequate market information. Since the farmers have little or no capacity to process their produce and coupled with the fact that there are no modern storage facilities, their products are prone to damages and post-harvest losses (Kader, 2005). Even when the farmers decide to take their produce to the market, they are often constrained by problems of transportation such as poor road network and inefficient mode of conveying their produce to the market.

Poor postharvest handling practices induce damages to fresh produce which include splitting, tearing, internal bruising, superficial wounds and crushing of soft produce. Poor handling can thus result in development of entry points for mould and bacteria, increased water loss and an increased respiration rate (Kereth et al., 2013). Mechanical injuries are major causes of losses in the quality and quantity of fresh horticultural commodities in all handling systems. The incidence and severity of mechanical injury can be greatly minimized by reducing the number of steps involved in harvesting and handling and by educating all personnel involved, about the need for careful handling (Kader, 2004).

Kader (2005) argued that the level of contamination could be greater due to the use of contaminated field package, dirt water for washing produce before packing, decaying, rejected produce lying around packing area and unhealthy produce contaminating healthy ones in the same package. The need to control high perishability and safe handling involves specialized production, packing techniques and refrigerated transport, all of which require large capital investments and also investment in research, development and marketing (Kirsten, 2002) which smallholder farmers cannot easily afford. Smallholder farmers lack an intimate knowledge of postharvest

treatment such as cold chain management and traceability which is critical to lengthen their short shelf life and reducing wastage (Louw et al., 2008).

Postharvest handling and storage of fresh produce needs to ensure that the produce maintain appearance, sensory and keeping qualities to penetrate and secure access to niche markets. Some special tools and/or equipment in harvesting and postharvest handling such as containers, equipment for cleaning, waxing, and packing, and cooling facilities may not be available in domestic markets or available but at exorbitant prices, thus becoming unaffordable to most smallholder farmers (Kader, 2005). Naturally, fresh produce needs low temperature and high relative humidity during storage and transportation. Low temperature decreases physiological, biochemical and microbiological activities, which are the causes of quality deterioration (Getinet et al., 2008). On the other hand, higher relative humidity increases the vapor pressure of the air and decreases physiological weight loss of commodities. Proper management procedures that include the selection of optimum time to harvest in relation to product maturity and climatic conditions, training and supervision of workers, and proper implementation of effective quality control (Kader, 2004) becomes very critical.

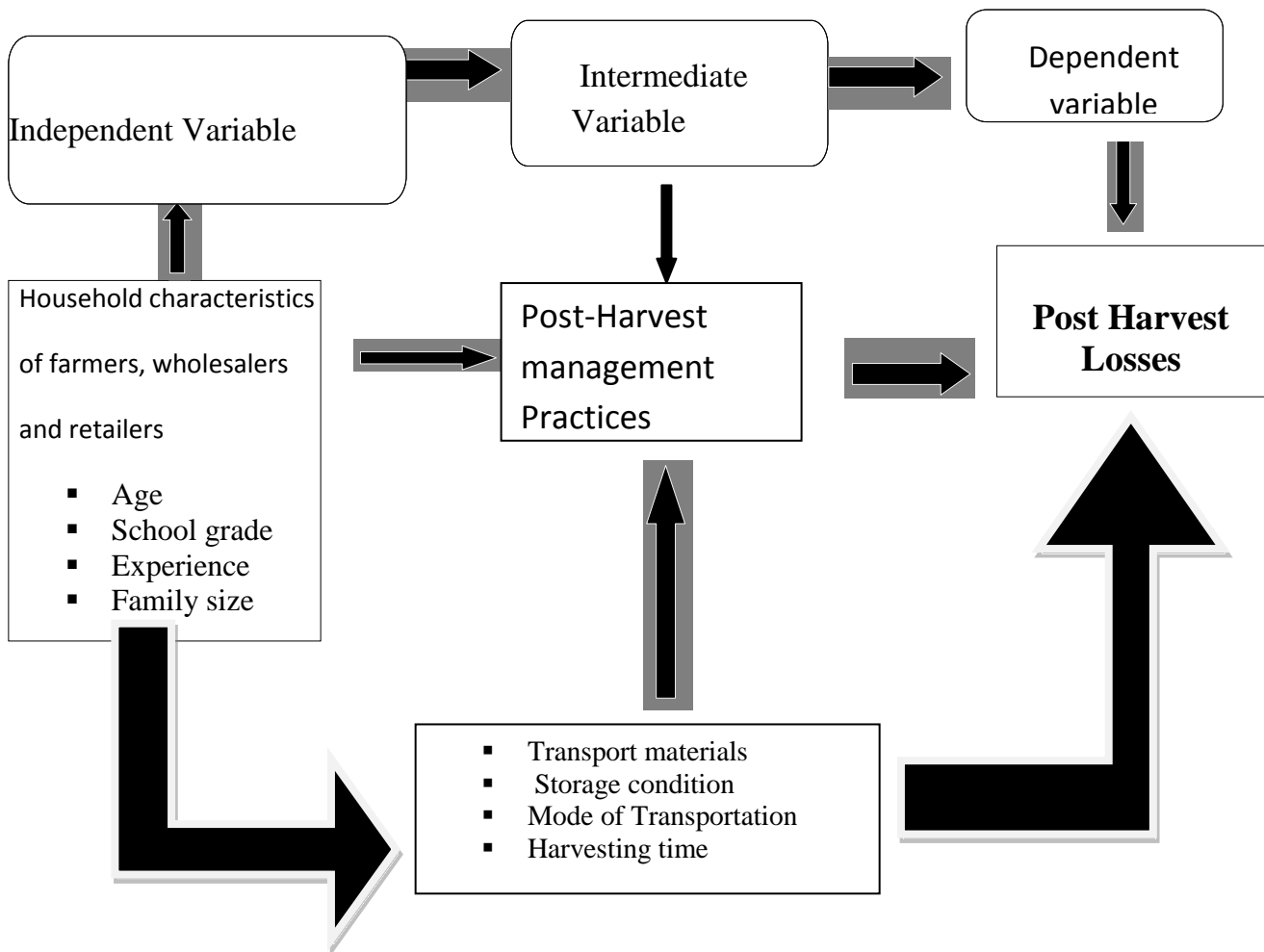
Vegetables have high moisture content and are rich in nutrients and thus naturally contaminated with microbes; therefore, keeping the number of microorganisms as low as possible by keeping a clean environment is very critical (Lehto et al., 2011). Improper harvest and postharvest practices result in losses due to spoiling of the product before reaching the market, as well as quality losses such as deterioration in appearance, taste and nutritional value (Babalola et al., 2010). However, most handlers involved directly in harvesting, packaging, transporting, and marketing in developing countries have limited or no appreciation for the need for, or how, to maintain quality (Kader, 2004).

2.3. Conceptual framework

Post-harvest food loss (PHL) is food lost along the supply chain from harvest until consumption. The tomato postharvest losses is influenced by factors such as harvest techniques, harvesting time ,packaging material, storage system and duration. Inappropriate Tomato storage is facing to Spoilage, Improper handling and Time (duration) or shelf life of the product. The lack of adequate packaging leads to transportation losses while moving this packaged product to the

market. Poorly-packaged foods lose moisture quickly when exposed to unfavorable conditions, contributing in turn to food losses. These losses can be greater if poor-packaging is accompanied by poor-logistics for marketing. Poor market logistics is a big concern in less developed food. The tomato post-harvest losses is influenced by factors such as harvest techniques, harvesting time ,packaging material, storage and selling place sanitation.

Figure 1 Conceptual framework



Source: Modified from(Eman model,2015).

3. MATERIALS AND METHODS

The methods and materials were presented in this chapter, which consists of five main sub-sections. The first sub section describes geographical description of the study area. The Second section describes research design and approach. The third section discusses the data collection procedure, and the sampling procedure is described in the fourth section. The fifth section discusses in detail about methods of data analysis.

3.1. Geographical description of the Study area

The study was carried out in 2019 in two *kebeles* (Godino and Denkaka) located in East Shewa Zone of Oromia National Regional State, Ethiopia, about 45Km South east of Addis Ababa. Adea Wereda's administration office is located in Bishoftu town. The center of the town is located Latitude: 8° 56'-8.95' N and 38° 80'-39° 19" E longitude (CSA, 2007). Farmers from two kebeles they supply tomato product to Godinotera market centre. It is bounded by Lume Wereda in the East, by Akaki *Wereda* in the West, by Bora and Liben Zukala Wereda in the south and by Ginbichu Wereda in the north. The total land area of the *Wereda* is 96,680 hectares and out of this, 79,517.32 hectare of land was under cultivation. The *Wereda* is divided into three agro-ecology zones; that is, *Dega* 3%, *Woinedega* 94 % and *Kola* 3% respectively. The *Wereda* has the potential for both crop and livestock production, which is mainly undertaken by small holder farmers. The agro-ecology in the *Wereda* is best suited for diverse agricultural production. There are a number of rivers and creator lakes that are being used for irrigated agriculture, particularly for horticultural crop production. The *Wereda* is nationally known for its best quality Teff production, which dominates the agricultural production system. Teff is a dominant cereal crop which occupies about 45% of cultivated land. Other major crops produced in the *Wereda* include lentil, horse bean and horticultural crops mainly vegetables. The average annual temperature in Adea is 18.7 in a year average rain fall is 892mm.(www.National Metro agency orga.gov.et). Altitude of the Wereda ranges from 1500 m to over 2000 meter above sea level. The study area Godino and Denkaka *kebele* is 12km and 9kms far away from Bishoftu town respectively. The 2012(SCA) national census conducted by the Central Statistical Agency of Ethiopia had an estimated total population of 355, 343 of whom 175, 788 were men and 179,555 were women.

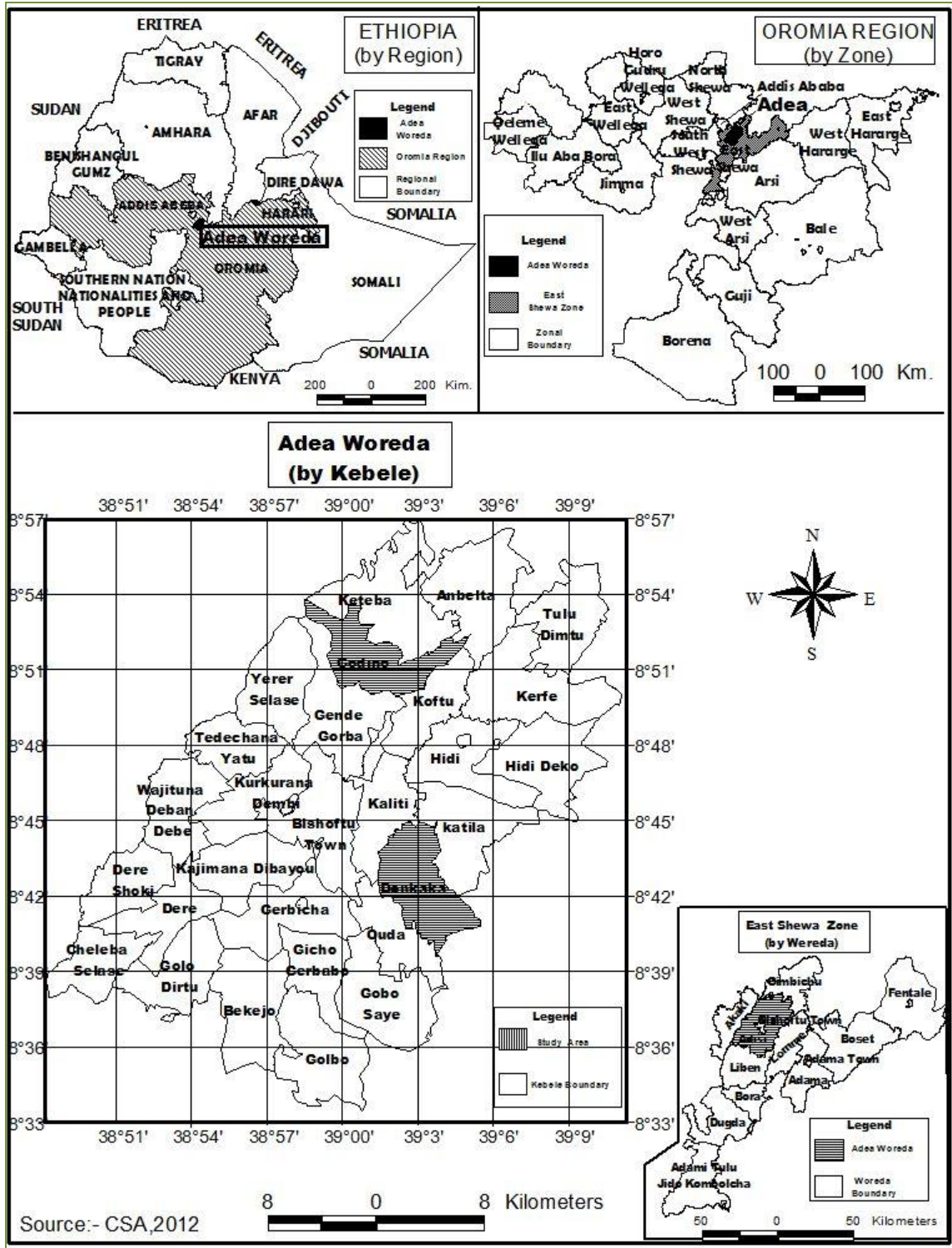


Figure 2 Map of Adea Wereda

3.2. Research design and approach

A cross-sectional study is undertaken to investigate tomato handling practices and postharvest losses along its supply chain. In order to build as comprehensive understanding as possible, a “mixed methods” approach both qualitative and quantitative was employed in the study to generate the first-hand data. A cross-sectional questionnaire-based household survey was conducted in Adea *wereda*. The descriptive statistics was used to determine the household’s characteristics which including percentage, mean, standard deviation, range and frequencies.

The Tobit method is used to know the relationship between dependent and independent. The data which was collected through interview was analyzed qualitatively. The participatory qualitative methods used in the research include Key Informant Interview and field observations.

3.3. Sampling techniques and sample size

Multistage sampling procedures were employed to select the samples from tomato producers, wholesalers and retailers. Adea *Wereda* was purposively selected from East Shoa Zone as the first stage sampling procedure. In the second stage tomato farmer’s in Adea *Wereda*, two *kebeles* (Godino and Denkeka) were selected based on volume of tomato production. In addition to this the geographically location is comfortable for agricultural production. The list of both 10 wholesalers and 103 retailers were obtained from *wereda* Trade and Industry office. In the third stage 10 wholesalers selected census. In the fourth stage from 103 lists of retailers 30 were selected by using systematic sampling techniques every 3rd. The two hundred twenty two (N=222) is the total sample of the respondents. Yamane (1967) provides a simplified formula to calculate sample sizes.

$$n = \frac{N}{1+N(e)^2} = 334/1+334(0.05^2) = 182$$

n= Sample

N= Total number of population e= Errors

3.4. Data types, Source of data and data collection techniques

3.4.1. Data types and source of data

The research was used both qualitative and quantitative type of data in order to answer the research questions and thus arrive at concrete conclusions. The researcher was also used both primary and secondary source of data. Primary data was collected questionnaire from the farmers, wholesalers and retailers. The Secondary data were collected from several published and unpublished literatures such as postharvest losses of tomato and marketing constraints, journal on handling practices of tomato and its postharvest losses. Data were analyzed by using descriptive statistics such as percentages, frequencies, mean deviation and standard deviation. The primary data were collected from farmers, retailers and wholesalers in the study area.

3.4.2. Method of data collection

The primary data was collected which included the field survey of tomato postharvest handling practices along supply chain and its postharvest losses. Survey questionnaires, observations and Focus Group Discussions (FGD) were employed. The interviews and focus group discussions held by Amharic and Afan Oromo language. Structured questionnaires administered to respondents including tomato producer's farmers, and wholesalers and retailers. Farmers and Agricultural Developmental Experts were interviewed using questionnaires with open and closed questions. The question sought to obtain the information on tomato handling practices and its postharvest losses at along supply chain (harvesting, storage, transporting and marketing).

3.5. Techniques of data analysis

Data collected from the study area was analyzed by using descriptive and Tobit stata. The descriptive statistics analysis which includes (means variance, range, chi-Square, frequencies and standard deviations of the variables). Cross tabulation and chi-square tests were done on some variables to check for any significant associations and relationships between variables. Tobit models were employed to test the significance of the factors affecting postharvest losses of tomato and handling practices along supply chain. After data collection was carried out, by using SPSS software (Statistical Package for Social Science) the data was coded and entered into

computer finally analyzed the analyzed the results. Based on analyzed data the interpretation was taken place.

3.6 Description of variables and measurement

3.6.1 Dependent Variable

In this study the quantify loss of tomato is the dependent variable which can be affected by a number of independent variables. It is defined as dummy variable with values of 1 for practice of packaging tomato and 0 otherwise. Age, household size and experience in farming/trading of the respondents were measured at interval level while educational level and marital status, etc. were considered as independent variables.

3.6.2 Independent Variables

The variables that affecting tomato postharvest losses it combined effects of various factors such as harvesting method , time of harvesting, inappropriate storage & packing/handling materials ,grading and sorting, mode of transportation, and shelf life (duration).

Age

This variable is continuous measured in year. Age of the farmers considered as one of the independent variables influencing the post-harvest losses at the farm level. This age might not be appropriate for strenuous farm activities like land preparation, weeding, planting, heaping and harvesting and as a result may negatively affect production by leading to technical inefficiency,

Sex

The variable represents the biological characteristics of being male or female. It is dummy variable with values of 1 if the household head is male and 0 otherwise

Level of Education

This is a dummy variable measured education status of the household head with values of 1 if the household head is literate (read and write) and 0 otherwise. The higher the educational level of respondents the lesser the quantity of fruit loss.

Family-size

This is the total number of family members under a household. It is a continuous variable expected to take positive coefficient. The higher number of family a household had the more quantity they would consume.

Sorting and grading

Tomato sorting was done by hand for the removal of color, bruised and contaminated, rotten, aged, or diseased fruits from the healthy and clean ones.

Transportation system

Transporting harvested tomatoes to the market on such bad road network and the lack of proper transportation like refrigerated vans become a big challenge for both producers and distributors.

Storage facilities

The adequacy of storage was represented by a dummy variable. Value ‘1’ was assigned to the dummy variable if the farmer had inadequate storage facility. Therefore, this variable is hypothesized to have a positive association with post-harvest losses. To examine the influence of transportation facility on post-harvest losses, a dummy variable was included among explanatory variables, which took the value ‘1’ if the farmer had inadequate transportation facilities. This variable is expected to have a positive association with

The Tobit model

Equation 1: to determine postharvest loss of tomato at farm level

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_{10} X_{10} + \epsilon_i(1)$$

Given;

Y = Post-harvest losses of tomato in kg per household,

X₁ = age :

X₂ = farm size in ha

X₃ = mode of transportation (MT), X₄ = storage system X₅ = time of harvesting, (X₆) = type of containers , X₇ = school grade (SG): X₈ = Experience in farming (Exp), and ε is error term and a = intercept **β₀ = intercept** **ε = error term**

Equation 2: to determine postharvest loss of tomato at Wholesalers

$$Y_2 = \beta_0 + \beta_1 W_1 + \beta_2 W_2 + \beta_3 W_3 + \beta_4 W_4 + \beta_5 W_5 + \epsilon(2)$$

Where:-

Y2 is wholesaler level postharvest tomato loss per kg;

W1 is school grade of wholesalers;

W2 is experience in tomato trade;

W3 is family size

W4 is storage facilities,

W5 is storage condition and ε is error term.

Equation 3: to determine postharvest loss of tomato at Retailers

$$Y3 = \beta_0 + \beta_1 R_1 + \beta_2 R_2 + \beta_3 R_3 + \beta_4 R_4 + \beta_5 R_5 + \beta_6 R_6 + \varepsilon \quad (3)$$

Where:-

Y3 is retail level postharvest tomato loss per kg; R1 is sex of retailers dummy (1 = female; 0 = male); R² is educational level of retailers; R3 is experience in tomato trade; R4 is family size, R5 is age, and R₆ mode of transport. ε is error term.

4. RESULT AND DISCUSSIONS

This chapter presents the main findings of the study. The first part discusses about the tomato handling practice and postharvest losses of tomatoes which are addressed in the first objective of the study. The household characteristics of tomato producing farmers, wholesalers and retailers associated with handling practices of tomatoes along supply chain. The results of socio-economic characteristics of respondents were computed by using descriptive statistical analysis such as t-test and chi-square. The Second section presents the constraints of tomato postharvest losses along supply chain that explained by Tobit model to address the second objective of the study. Lastly, Tobit stata was used to estimate and explain the value of tomato losses along supply from farm gate to retailers.

Table 1. Tomato producing Household characteristics

Household characteristics		Non Adopters %	Low Adopters %	Medium Adopters %	High Adopters %	Test Statistics
Sex	F	3	10.5	11	81.8	0.432
	M	18.2	89	89.5	97	
Age	26-30	0	5	9.1	10.5	0.012**
	31-41	23.7	27.3	42	36.4	
	42-59	18.3	66.7	75	85.7	
age mean	40.62(7.482 Sd)					
Education level	illiterate	27.3	39.5	43	63.6	0.761
	read and write	18	23.7	27.3	30.3	
	grade1-8	9.1	18.1	18.2	24	
	grade9-12	0	5	6.1	7.9	

Marital status	Married	0	0	2.6	2.6	0.581
	Single	0	0	5	5.3	
	Divorced	92	92.1	100	100	
Experience in farming	1-5	0	2.6	2.6	3	0.807
	6-10	0	5.3	6	9	
	11-15	12.5	16	18.2	24.1	
	Above 15	7	9.1	9.1	35.1	
Family size	1-5	5.8	54.5	54.5	71.1	0.438
	6-10	7.5	23.7	42.4	45.5	
	Above 10	0	0	0	0	

Note: ***, **, * variable is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

4.1. Tomato producing household characteristics

The result indicated that the distribution of the sample households were as shown in table-1 the sex with the adoption of 3% 10.5%,11% and 81.8% non-adopter, low adopter, medium adopter and high adopter for female and 18.2%,89%, 89.5%and 97% for male respectively. Female farmers less post-harvest losses of tomato at farm level. Post harvest losses of tomato faced high at male farmers. This indicted that post harvest management practicing more excising at female farmers which means low post harvest losses of tomato at farm level. In the case of Marital status of the respondent's married 0%, 0%,2.6% and 2.6%), single (0%, 0%,5& 5.3%) and divorced (92%, 92.1%,100%&100%) non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. Divorced respondents were high tomato post harvest management practicing than married and single. The married farmer less post harvest management practice than single and divorced which mean high losses. The percentage shows 0% non adopters means

high post harvest losses or low post harvest management practicing at farm level. In terms of age 26- 30 were 0%,5%,9.1% and 10.5% non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. At 26-30 was 10.5% of high adopter or post-harvest package practice farmers which means decreasing tomato post-harvest losses at farm level. Age ranges from 31-41 was 23 %,27.3%,42% and 36.4% non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. Age of the respondents were ranged between the ages of 42-59 was 18.3%,66.7%,75% and 85.7% non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. As the age of farmers increasing post harvest management practices is more practicing. On the other hand the older farmer low tomato post harvest losses than younger farmers. Educational level of the farmer respondents such as illiterate 27.3%,39.5%,43%,and 63.6% had no formal education 18%,23.7%,27.3% and 30.3%, grade 1-8 or primary education 9.1%,18.1%,18.2% and 24%, secondary education and tertiary education was 0%,5%,6.1% and 7.9% non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. Experience in farming was ranges from 1-5 years experience 0%,2.6%,2.6% and 3%,6-10 years experience years 0%,5.3%,6% and 9%,11-15 years experience 12.5%,16%,18.2 % and 24.1% and above 15 experience in years 7%,9.1%,9.1% and 35.1% non adopter, low adopter, medium adopter and high adopter of the farmer's respectively. Family size of the farmers' ranges from 1-5 were 5.8%,54.5%,54.5% and 71.1% non adopter, low adopter, medium adopter and high adopter, from 6-10 family size 7.5%,23%,72.4% and 45.5% non adopter, low adopter, medium adopter and high adopter respectively. Average age mean of farmers 40.62. Age of the farmers affect the tomato post-harvest management practices. Age of farmer's respondent statically significant less than 0.05. Sex, marital status, education level, experience in farming and family size of farmers were not affect post-harvest management practices.

Table: 2 Post-harvest management practices of tomato at farm level

Post-harvest practices	Non Adopters %	Low Adopters %	Medium Adopters %	High Adopters %	Test Statistics
Time of harvest	9.1	28	39.4	73.7	49.0532***
Cleaning and washing	18.2	53	54.5	100	0.278***
Sorting and grading	9.1	74	60.6	100	0.245***
Mode of Transportation	9.1	86	87.9	100	0.007***
Proper loading and unloading	0	40	36.4	76.3	0.982***
packing of tomato by carton after harvest	0	12	30.3	100	1.185***

Note: ***, **, * implies statistics is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

Post-harvest management practices of tomato at farm level. The results from table 2 above show that the time of harvesting 9.1%, 28%, 73.7%, 39.4% and 73.7% non adopter, low adopter, medium adopter and high adopter respectively. 0%, 40%, 36.4%, 76.3% non adopter, low adopter, medium adopter and high adopter respectively. Sorting and grading 9.1%, 74%, 60.6% and 100% non adopter, low adopter, medium adopter and high adopter respectively. Proper loading and unloading 9.1%, 86%, 87.9% and 100% non adopter, low adopter, medium adopter and high adopter respectively. Tomato postharvest management practices of harvesting mode of transportation, time of harvesting, cleaning and washing, sorting and grading and unloading of tomato without and packing tomato by carton after harvest were highly significant at 1%. From six post harvest management practicing of tomato's cleaning and washing practicing was low practicing which means 18.2% of non adopters or which means high post-harvest losses tomato at farm level. Therefore there were high tomato post-harvest losses manifested. Low adopter means high tomato's post-harvest losses. High adopter tomato's post-harvest management practice means there were good post-harvest management or no postharvest losses of tomato at farm level.

Sorting and grading, packing of tomato by carton after harvest, cleaning and washing and transporting material were high adopted at farm level.

Table: 3 Postharvest Management Practices of wholesalers

Postharvest Management Practices of wholesalers	Non Adopters %	Low Adopters %	Medium Adopters %	High Adopters %	Test Statistics
Containers materials	9.1	28	39.4	73.7	.000***
Storage condition	18.2	53	54.5	100	.000***
Cleaning and washing	9.1	74	60.6	100	.000***
Sorting and grading	9.1	86	87.9	100	.000***
Mode of transport	0	40	36.4	76.3	.000***

Note: ***, **, * implies statistics is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

The results from table 3 show that the Containers 9.1%,28%,39.4% and 73.7% non adopter, low adopter, medium adopter and high adopter at wholesalers level respectively. The Storage condition 18.2%,53%,54.5% and 100% non adopter, low adopter, medium adopter and high adopter respectively. Cleaning and washing 9.1%,74%,60.6% and 100 %non adopter, low adopter, medium adopter and high adopter respectively. Sorting and grading 9.1%,86%, 87.9% and 100% non adopter, low adopter, medium adopter and high adopter respectively. Mode of transport 0%, 40%, 36.4% and 76.3% non adopter, low adopter, medium adopter and high adopter respectively. Cleaning and washing, storage condition, sorting and grading, and transporting material were significant affect tomato postharvest management practice at wholesalers.

Table:4 Postharvest Management Practices of retailers

Postharvest practices retailers	Non Adopters %	Low Adopters %	Medium Adopters %	High Adopters %	Test Statistics
Tomato containers	0	0	57	100	.0001***
Storage condition	43.8	50	57.1	57.1	0.867
Cleaning and washing	0	18.8	25	33.3	.522
Sorting and grading	25	33.3	36.7	57.1	.471
Transportation	0	42.9	93.8	100	.001***

Note: ***, **, * implies statistical is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

Results from table 4 tomato's Containers 0%, 0%, 57% and 100 % non adopter, low adopter, medium adopter and high adopter at retailers' level respectively. Storage condition 43.8%, 50%, 57.1% and 57.1% non-adopter, low adopter, medium adopter and high adopter retailers level respectively. Cleaning and washing 0%, 18.6%, 25% and 33.3% non adopter, low adopter, medium adopter and high adopter retailer's level respectively. Sorting and grading 25%, 33.3%, 36.7%, retailers level and 57.1% non adopter, low adopter, medium adopter and high adopter retailers level respectively. Transportation 0%, 42.9%, 93.8% and 100% non adopter, low adopter, medium adopter and high adopter retailers level respectively. Containers the retailers using and mode of transportation were significant affect tomato postharvest management practice retailers' level.

Table 5. Tobit regression results of tomato post-harvest management practices at farm level.

Variables	coefficient	Standard deviation
Sex	-0.000 ***	0.000
Age	0.000***	0.000
Marital status	0.000***	0.000
Level of Education	0.000 ***	0.000
Family size	0.000 ***	0.000
Experience in farming	0.000***	0.000
Time of harvesting	- 0.000***	0 .000
mode of Transport	-0.001 ***	0.000
Cleaning and washing	0.001***	0.000
Sorting grading	0.001***	0.000
Packing by carton	0. 000 ***	0.000
Loading and unloading	0.000 ***	0.000
Training	0.000***	0.000
Marketing information	0.000 ***	0.000
Constant	0.002***	0.000
LR Chi2 (0.89)	0.89***	
Number of observation (N)	182	

Note: ***, **, * implies stastical is significant at 1%, 5% and 10% respective Source: Own Survey data (2019)

Table-5 indicated that age, marital status, level of education, washing and cleaning, family size, experience in farming, mode of transportation, sorting and grading, loading and unloading, training, packing by carton and marketing information positively significant affect tomato post harvest management practices at farm level at p-value 0.000 or 99%. Whereas, the Sex, time of harvesting and mode of Transport were negatively significant affect tomato post harvest management practices at farmers level at p-value 0.000 or 99%.

Table 6. Tobit regression results tomato post-harvest management practices at wholesaler's level.

Variables	coefficient	standard deviation
Age	-.315695	.0910803
Sex	-.9161887*	.5167637
Experience	.5008036	.1381298
Marital status	-.0157629**	.1736914
School grade	.1591546	.0782268
Family size	.0509598 *	.2379803
Mode of transporting	0.476	0.017
Cleaning and washing	0.450	0.024
Sorting and grading	0.051*	0.017
Loading and unloading	50.813	0.000
Constant	0.0471**	0.0422
LR chi2 (7.14)	7**	
Number of observation(N)		10

Note: ***, **, * implies stastical is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

Table 6 Censored tobit regression revealed that family size and sorting and grading positively significant affect tomato post-harvest management practices at wholesalers level at p- value < 0.05 or 95%. Sex and marital status was negatively significant affect tomato post-harvest management practices at wholesalers level. School grade, age, experience, mode of transporting, cleaning and washing and loading and unloading were not affect post-harvest management practices of tomato at wholesalers' level.

Table 7. Tobit regression results for tomato post-harvest management practice retailer level.

Variable	coefficient	Standard deviation
Age	-0.007**	0.015
Marital status	0.028**	0.013
Level of education	0.006**	0.003
Family size	-0.014 **	0.010
Experience in trading	0.012**	0.002
Mode of transporting	-0.026 **	0.015
Cleaning and washing	-0.158	0.024
Sorting and grading	-0.113	0.014
Containing by carton	-0.396	0.017
cold storage	0.037**	0.014
constant	0.0404 **	0.026
LR chi2 (0.99)	0.99**	
Number of observation(N)	30	

Note: ***, **, * implies statistical is significant at 1%, 5% and 10% respectively

Source: Own Survey data (2019)

Table 7 shown marital status, Level of education, experience in trading and cold storage were positively significant affect tomato post harvest management practices at retailers' level. Age, mode of transporting and family size negatively significant affect tomato post-harvest management practices at retailers' level. Washing and cleaning, Sorting and grading and packing in carton don't affect tomato post harvest management practices at retailers level.

4.2. Postharvest loss of tomato

To calculate the amount of tomato at different stages such as farmer's level, wholesaler's level and retailer's levels Calculated by using formula's the percentage of tomato losses equal to quantity of tomato losses divided by quantity of tomato produced multiplying by 100.

4.2.1 Postharvest loss of tomato farmer's level

$$\text{Percentage of losses} = \frac{\text{Quantity of tomato loss}}{\text{Quantity of tomato produced}} * 100$$

In the below table shows that the Percentage of tomato losses at farm level in 2009 E.C is 17.6% and 2010 E.C is 16.04%. When these losses calculated into birr the amount of loss multiply by unit price for example in 2009 E.C, 7943 quintal loss multiply by average of tomato price at farm level the resulted 7,148,700 birr. In 2010 E.C, 7754Qt is the amounts of tomato loss at farmer level multiply by unit price (1000 birr per quintal) which accounts 7,754,000 birr loss. This shows that quantity of tomato loss has impact on farmer income. An individual farmer income lost from tomato selling revenue average in 2009 and 2010 E.C in Ethiopia birr 39,278.57 and 42,604.39 loss respectively.

Table: 8. Postharvest loss of tomato at farmer's level

Tomato	Year	
	2009 E.C	2010 E.C
	Total Production in (Qt)	45130
Amount loss in (Qt)	7943	7754
Percentage in (%)	17.6	16.04
unit Price in Birr/Qt	900	1000
Monetary Value	7,148,700	7,754,000

Source: Survey data (2019)

4.2.2. The percentage of tomato losses at wholesale level

Percentage of tomato loss is equal to quantity losses of tomato loss divided by quantity of produced multiply by 100. Percentage of losses = $\frac{\text{Quantity of tomato loss}}{\text{Quantity of tomato purchased}} * 100$.

Percentage of tomato losses at wholesalers .4027% (percentage) and 0.2689 losses at wholesaler 2009 and 2010 E.C respectively. The amount of tomato losses at wholesaler in 2009E.C is 160 quintals, then converting this loss into birr and by multiply the average selling price tomato at wholesaler which accounted into birr 184,000 birr. In 2010 year 113 amount of quintals losses at wholesale when converted into 135,600 birr loss at wholesalers. An individual wholesaler income gain from tomato selling in average in 2009 and 2010 E.C in Ethiopia birr 18,4000 and 135,600loss respectively.

Table.9.Postharvest loss of tomato at wholesale level

Tomato	Year	
	2009 E.C	2010 E.C
Total Production(Qt)	9730	42012
Amount loss (Qt)	160	113
Percentage (%)	0.40	0.27
unit Price birr	1150	1200
Monetary Value	184,000	135600

Source: Survey data (2019)

4.2.3 Percentage of tomato losses at retailer's level

The percentage of tomato losses at wholesale level calculated by using formula: Percentage of tomato loss is equal to quantity losses of tomato loss divided by quantity of produced multiply by

$$100. \quad \text{Percentage of losses} = \frac{\text{Quality of tomato loss}}{\text{Quantity of tomato purchased}} * 100.$$

The percentages of losses at wholesaler were0.474 % and 0.51 (percentage) losses at 2009 and 2010 E. C respectively. The amount of tomato losses at retailer's in 2009E.C was 25.6 quintals, then converting this losses into birr and by multiply the average selling price tomato at retailer's which accounted into birr 30,720 birr. In 2010 year about -19.7 quintals losses estimated at wholesale when converted into 25,649 in Ethiopian birr loss at retailer's. An individual retailer's income gain from tomato selling average in 2009 and 2010 E.C in Ethiopia birr 1,024 and 854.966 loss respectively.

Table10. Postharvest loss of tomato at retailer's level

Tomato	Year	
	2009 E.C	2010 E.C
Total Production(Qt)	5400	4320
Amount loss(Qt)	25.6	19.7
Percentage %	0.47	0.51
unit Price per birr	1200	1300
Monetary Value	30,720	25649

Source: Survey data (2019)

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study concludes that Post harvest management practices of tomato were significant affect age, marital status, level of education, washing and cleaning, family size, experience in farming, mode of transportation, sorting and grading, loading and unloading, training, packing by carton and marketing information highly positively significant affect tomato post harvest management practices at farm level. The total postharvest losses accounted 16.82 % of tomato losses occurred at farmer's level. The total percentage of Post-harvest loss at wholesalers and retailers was 0.485% and 0.49% respectively.

Tomato's Post-harvest losses high at farm level, when compare to losses at retailers and wholesalers due to poor handling practice, lack of adequate storage, unscientific method of harvesting operations and lack of ready market not only reduce the of the market to immediately sell the product the harvest. The monetary value of tomato losses at farm level in birr is in 2009E.C 7,148,700birr and in 2010E.C.7, 754,000 birr. At wholesalers in 2009E.C. 184,000birr and in 2010E.C. 135,600 birr losses. At retailers in 2009E.C.30,720 birr and in 2010 E.C.25,649birr losses. Minimizing post-harvest losses and improving handling practices has major contribution for producers and traders of tomato and can an increasing the food availability and access throughout the year. Improving tomato postharvest management would be reduced post-harvest losses, production of value added products, effective and efficient research programs on the post-harvest sector must be strengthened and promoted.

5.2 Recommendations

Based on the findings of the study, the following recommendations are made improving tomato handling practices. Tomato post harvest management practices would be attained by improving transportation facility, storage condition and conducive retail shops in accessible site.

- Farmer harvesting of tomato at coolest time in the morning or late afternoon to minimizing tomato post harvest losses at different stages.
- Farmers and traders in study area will apply post harvest practice that supported with technology such improved storage, cold chain transportation system, containers or packaging material protect tomato from physical damage.
- Farmer, wholesalers and retailers to be applied appropriate postharvest management and treatment methods along supply chain at farm level, wholesaler and retailers level to increase the shelf life of tomato.
- Adea wereda's agricultural development office will strengthen and capacitate the farmer's knowledge and awareness about post harvest management practice and losses by providing training effectively.
- Adea wereda's trade and industry office and Agricultural development office will work in corporately to make market linkages between producers to the retailers and producers to wholesalers.
- The agricultural sector will be focus on how to minimizing post harvest losses that reducing food availability and access.

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Appendix I: Questionnaires

I. Respondent's General information

1.1. Questionnaire no: _____ 1.2. Date of interview (DD/MM/YYYY): _____

1.3. Zone: _____ 1.4. District: _____

1.5. Peasant Association (Kebele) _____

Personal Profile

No	Categories	Code
1	Age in years	
2	Marital status	
3	School grade	
4	Sex	

Code for:

Marital status 1=Married, 2= single, 3 separated, 4 =Widowed, 5=divorced

Code for Education level, 1= grades 1-4, 2= grades 5-8, 3= grades 9-10, 4= (11-12),
5=University/Collage and above

Sex 0 for male and 1 for female

1. How many of your family members do permanently work on farm activities: _____

2. Who mostly participate on tomato harvesting 0, male 1, female

3. At what stage of maturity farmer harvesting tomato? (Multiple answer possible)

a, Green mature [] b, immature [] c, Red ripe []

4. How long you wait till you find buyer: _____ days/ hours

5. What are the main uses of tomato in 2009/10 E.C?

a, For consumption b. For sale c, for animal feed

6. What is the annual income of tomato farmer production in year 2009 and 2010

vegetable	Total production last year (quintal)	Total production this year (quintal)	Current year production value /in Birr
Tomato	(...quintal)	(... quintal)	

7. How much loss of tomato faced annually?

In 2009 year E.C _____kg

In 2010 year E.C: _____kg

8. Estimate of loss of percent for tomato along supply chain channels?

- On the way transporting to store: ____ %
- Use of improper packaging material: ____%
- Inappropriate storage: _____%
- At farm level to wait buyers? ____%

9. What type packaging material do you use for the movement of tomato market?

- a, plastic crate [] b, wooden-box []
 c, cartons [] d, basket

10. How long do you travel from farm gate to market place? In Km: ____minutes

11. What technique do they use to let the tomato ripen?

A. Putting on a plain on wood B. putting on plain metal sheet c. putting on warm floor d. putting in closed bag...e, other specify

12. How do you sell your product? (Multiple answer possible)

1. Direct to the consumer 2. To wholesaler 3. to retailer 4. other (specify) -----

13. Who determine the price for tomato product during purchasing at farm?

- a, farmer b, wholesaler c, consumer d, retailer e, brokers

14. Do you think that you get fair price for your product 1,NO. Yes 0,..No

15.If the answer is No17 what could be the reason? (Multiple answer possible) a, due to weak market organization B, due to lacking access to right marketing place c, due to fragile coordination between farmers d, due to bargaining power of other intermediaries

16. Where do you get marketing information to sell your product? 1.from friend 2.fellow farmer 3. Broker

Questions	Yes	No
	1	2
17. Did you get training regarding tomato handling practices and post-harvest losses?		
18. Do you grade tomatoes before packing?		
19. Do you think using post-harvest technologies can minimize losses?		
20.Do you use of improved storage		
21. Do you use of improved transportation		
22. Are you often able to prolong the shelf life of your goods?		
23. Do you use technology to harvesting tomato?		

Part III. Constraints that adversely affect tomato handling practice and post-harvest losses.

Direction: -The below listed questions are to identify the constraints that affect handling practice and post-harvest losses of tomato. Please put the tick mark (√) in the placed for each item.

5=very high 4= high 3=medium 2= low 1= very low

No	Problems	Scales				
		5	4	3	2	1
1	Lack of appropriate Packaging materials					
2	attacked by pests and diseases					
3	Lack of appropriate storage facilities					
4	Exposure to sunlight					
5	Waiting the buyers					
6	Lack of cold storage					

7	Severity of delayed harvesting time of tomato					
8	Grading or sorting problems(size, color grading) Problems					
9	Lack of appropriate harvesting tools					
10	Lack of food processing plant nearby farm					
11	Long distance from farm to market					
12	Mechanical damage(bruising due to sudden drop down floor)					
13	Lack coordination between farmer to trader					

IV. Please write your opinion regarding tomato handling practice and postharvest losses along supply chain.

1. What do you think the cause for the PH losses tomato? _
2. What do you think the way to minimizing tomato postharvest losses

A questionnaire for Wholesaler/Retailer

Categories	Code
Age in years	
Sex	
Marital status	
Education level of the respondent	

Code for: Marital status 1=Married,2= single,3 divorced,

Code for Education level, 1= grades 1-4, 2= grades 5-8, 3= grades 9-10, 4= (11-12), 5=University/Collage

Part II. Postharvest loss of tomato

1.How much loss do you faced annually?

In 2009 year E.C: _____ kg

In 2010 year E.C _____ kg

2. Experience in tomato trading (years)_____

3. Family size_____

4. Estimate the total tomato loss in different stages.

a, on the way transporting to store: ____ kg;

b, use of improper handling or packaging material: ____ kg

c, inappropriate storage: _____ kg

d, use of improper display material? ____ kg

5. What packaging material do you use during storing the product, in most cases this year?

a, Shallow wooden boxes [] b, Long big wooden boxes []

6. How long do you travel from farm gate to market place? in Km _____; in hours walk: ____

7. Do you pack Tomato while transporting to the local market? 1) Yes 0) No

8. What type of packaging material did you use this year?

1) Basket 2) Sack bag 3) Others (specify) _____

9. How long do you keep tomato maximum before selling? ____ day

10. What technique do you use to let the tomato ripen?

A. Putting on a plain on wood B. putting on plain metal sheet C. putting on warm floor D.

putting in closed bag E, other specify

11. At what stage of maturity do you buy tomato? (Multiple answer possible)

a. Green mature [] b, immature [] c, Red ripe []

Questions	Yes	No
12. Did you obtain training regarding to tomato handling practice and its post-harvest losses?		
13. Do you grade tomatoes before packing?		
14. Do you have appropriate packaging and storage for your product?		
15. Do you pack Tomato while transporting to the local collection site?		
16. Do you think that farmer get seasonable price for their produces		
17. Do you get price information deciding to sell?		
18. Do you sell at low price due to fear of damage while keeping till finding buyers?		

Part III. Problem Faced by wholesaler/Retailer and intermediaries handling practice and its post-harvest losses. Please put the tick mark (√) for each statement.

No	Problems	Extent of Problem				
		5	4	3	2	1
1	Lack of appropriate Packaging materials					
2	attacked by pests and diseases					
3	Absence of post-harvest treatment					
4	Exposure to direct sunlight					
5	Lack of buyers					
6	lacking access to right marketing place					
7	Lack of training and experience?					
8	Long distance from farm to market?					
9	Lack between farmer and trader?					

Post-harvest losses at Market place

- How much Tomato in kg
 - In 2009 year-. Kg. ____
 - In 2010 year kg ____
- How long you wait till you find buyer: ___days/ hours
- Who determine the price for tomato product during purchasing from farm?

A, farmer B,Wholesaler C, consumer D, retailer E, local trader F, brokers
- Who has more power while negotiating price for more perishable vegetable produce?

A, Farmer B,Wholesaler C, Consumer D, Retailer
- Who do you sell your product?

A, at farm-gate B. at home C, roadside D. Market place
- Estimate of loss of percent for mato along supply chain channels?
- What are the reasons behind for tomato to be unsuitable for market? Rank in their order of importance.

Reasons Rank

- Untimely harvest ____

2. Rough handling at loading and unloading ___
3. Poor packaging during transport ___
4. Long distance transport ____
5. Uncontrolled ripening environment__
6. Attacked by pest__
7. What do you think the cause for the losses?
8. What do you think the way to minimizing tomato post-harvest losses?

Key Informant Interview Guide for farmers and traders

My name is_____.Iam currently undertaking tomato handling practices and its post-harvest losses along supply chain, case of Adea Wereda, East Shao, Ethiopia. You have been purposely chosen to participate in this review for which we would like to appreciate your participation very much. The information you provide us will help farmer and traders in Adea to minimizing post-harvest losses along supply chain. The interview is expected to take a maximum of 45 minutes. Whatever information you provide will be kept confidential and will not be disclosed anywhere. Participation in this assessment is voluntary and you can choose not to answer any individual questions or all of the questions. However, I hope that you will cooperate to participate fully in this assessment since your views are important. .

1. What are the constraints and opportunities for Tomato marketing?
2. How can prolong or increases the shelf life of tomato?
3. What are the causes of tomato post-harvest losses?
4. What general outlook do you have over the post-harvest losses of Tomato?
5. What do you consider when setting the price of your produce?
6. What are the criteria to harvest tomato?
7. What do you recommend for minimizing post-harvest losses of tomato?

Thank you in advance for your cooperation!!

sortinggra~g	0.001	0.000	11.577	0.000	0.001	0.001
packingbyc~n	0.000	0.000	2.938	0.004	0.000	0.001
properlaod~g	0.000	0.000	2.233	0.027	0.000	0.001
stageharest	0.000	0.000	4.613	0.000	0.000	0.000
packmate	0.000	0.000	4.034	0.000	0.000	0.001
pestdisease	-0.000	0.000	-4.775	0.000	-0.001	-0.000
delhartito	-0.001	0.000	-8.464	0.000	-0.001	-0.001
coordfarnt~d	-0.001	0.000	-8.164	0.000	-0.001	-0.000
training	0.000	0.000	1.838	0.068	-0.000	0.001
information	0.000	0.000	0.854	0.394	-0.000	0.000
_cons	0.002	0.000	10.483	0.000	0.001	0.002

-----+-----
/sigma | 0.002 0.000 0.002 0.002

10 left-censored observations at p~handlinp~x <= 0

172 uncensored observations

Tobit regression for wholesalers

post~i	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
age	-.315695	.0910803	-3.47	0.026	-.5685745	-.0628155
sex	-.9161887	.5167637	-1.77	0.151	-2.350955	.5185774
maristatus	-.0157629	.1736914	-0.09	0.932	-.4980075	.4664817
loading andunlo	-0.135	0.026	-50.813	0.000	-1.381	-1.274
sorting	0.051	0.017	2.479	0.019	0.007	0.075
washinga	0.450	0.024	-6.683	0.000	-0.206	-0.110
modetr	-0.476	0.017	-22.630	0.000	-0.432	-0.360
schoolgrade	.1591546	.0782268	2.03	0.112	-.0580376	.3763469

```

housize | .0509598 .2379803 0.21 0.841 -.6097794 .711699
exptomatosell | .2948953 .120629 2.44 0.071 -.0400244 .6298151

_cons | 0.0471026 0.0422 3.66 0.022 1.800969 13.14108

```

```

-----+-----
/sigma | .5165473 .1266612 .1648793 .8682152
-----

```

Tobit regression for **Retailer**

Number of obs = 30

F(18, 30) = 0.99

Prob > F = 0.0000

Log pseudolikelihood = 8.7545617 Pseudo R2 = 0.0858

```

-----+-----
|          Robust
|          Coef. Std. Err.  t  P>|t|  [95% Conf. Interval]
-----+-----
groupeda | -0.007   0.015  -0.462  0.647   -0.037   0.023
maristat |  0.028   0.013   2.122  0.042    0.001   0.054
schoolgr |  0.006   0.003   1.663  0.106   -0.001   0.012
housize  | -0.014   0.010  -1.357  0.184   -0.034   0.007
packmate |  0.024   0.015   1.625  0.114   -0.006   0.054
pomarlik | -0.084   0.009  -9.605  0.000   -0.101  -0.066
concoold |  0.037   0.014   2.593  0.014    0.008   0.067
packmat  | -0.026   0.015  -1.693  0.100   -0.056   0.005
sortgrad | -0.113   0.014  -8.237  0.000   -0.142  -0.085
tomatopr | -0.044   0.006  -7.421  0.000   -0.056  -0.032

```

selallto	-1.328	0.026	-50.813	0.000	-1.381	-1.274
kappp	0.041	0.017	2.479	0.019	0.007	0.075
washinga	-0.158	0.024	-6.683	0.000	-0.206	-0.110
containe	-0.396	0.017	-22.630	0.000	-0.432	-0.360
prosortg	0.044	0.014	3.256	0.003	0.017	0.072
_cons	0.0404	0.026	92.001	0.000	2.350	2.457
-----+-----						
/sigma	0.168	0.000			0.167	0.168
