UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

ASSESSING POST-HARVEST HANDLING PRACTICES AND CHALLENGES AMONG TOMATO FARMERS AND RETAILERS IN SOME SELECTED DISTRICTS IN THE UPPER WEST REGION OF GHANA

CORNELIA TUOLIENUO

DECEMBER, 2020

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(200030399)

A Thesis in the Department of HOSPITALITY AND TOURISM EDUCATION, Faculty of VOCATIONAL EDUCATION, submitted to the school of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for the award of the Master of Philosophy (Catering and Hospitality) degree

DECEMBER, 2020

DECLARATION

STUDENT'S DECLARATION

I, CORNELIA TUOLIENUO, declare that this thesis with the exception of questions and references contained in published work which have all been identified and duly acknowledged, is entirely my own original work and it has not been submitted either in part or whole for another degree elsewhere.

SIGNATURE: …….

DATE: …….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines for supervision of thesis/dissertation/project as laid down by the University of Education, Winneba.

SUPERVISOR'S NAME: DR. GILBERT SAMPSON OWIAH

SIGNATURE: ……..

DATE: ……..

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DEDICATION

I dedicate this work to first and foremost the Almighty God for seeing me through my studies. I also dedicate it to my husband and children and to my mother, Mrs. Josephinne Tuolienuo for her constant prayers and support and to my siblings for their enormous efforts and encouragement.

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GLOSSARY/ABBREVIATIONS

FAO: Food and Agriculture Organization

DNA: Deoxyribonucleic acid

ABSTRACT

In most developing countries like Ghana, post-harvest loss of tomato has become a critical issue which bothers on the degree of produce perishability and inevitable cost to tomato handlers within the tomato value chain. The Post-Harvest Loss Value Chain Model was explored to critically analyse the post-harvest handling practices, examine the causes, challenges and treatment methods used by tomato farmers and retailers in four selected districts in the Upper West Region of Ghana namely Wa Municipal, Wa West District, Wa East District and Jirapa District. The mixed method research design was used for the study as the study employed both qualitative and quantitative source of data. The study population was all tomato farmers and retailers in the four selected districts in the Upper West Region. The sample size consist of forty-one (41) tomato farmers, fifty-seven (57) tomato retailers and four (4) Agricultural Extension Officers. The sampling techniques used were convenience and purposive. Survey questionnaires and structured interview were the instruments used to gather data for the study. Data from the study revealed that about 97% of tomato handlers harvested the produce in the morning in its matured ripped red state. About 42% of tomato handlers do not sort, grade and pre-cool their produce after harvest. The study established mechanical damage, infestation of pest and diseases, over ripening and poor packaging as some of the causes of post-harvest loss of tomato. Again, data from the study revealed that inadequate irrigation facilities, lack of storage facilities, poor road networks and inappropriate means of transport, low price of produce and high cost of production were the challenges facing tomato handlers. The study also found that sun drying of tomatoes was the common treatment method employed in the study area for preserving tomatoes.

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Vegetable production needs to be given prime concern so as to improve food security, increase farmer's income, and stop hunger especially in developing countries (Food and Agriculture Organization, 2010). Food insecurity often occur as a result of crop losses and this has a resultant unfavourable effect on the environment, economic development, and food quality. Globally, about 1.3 billion tonnes of food is lost every year. Water, land, managerial expertise, labour, and other inputs that could have been directed towards productive areas are all wasted because of crop losses (FAO, 2011). About 40% to 50% of vegetable crops produce are wasted annually and this is caused by mechanical bruises to the fresh produce, pest and disease infestations, and rot (Kitinoja, 2004). Post-harvest losses have therefore been considered to be one of the factors that influence food shortages in developing countries.

Post-harvest loss of tomato has become a critical issue that bothers on the rate of produce perishability and unavoidable cost to tomato handlers within the tomato value chain in developing countries such as Ghana (Babalola, Makinde, Omonona, & Oyekanmi, 2010). Post-harvest loss is a major challenge hampering tomato production in Ghana. Tomato being a perishable crop as a result of high moisture content has short shelf life of about 48 hours under tropical conditions (Arah, Ahorbo, Anku, Kumah & Amaglo, 2016). Special post-harvest handling practices and treatment methods are needed in order to extend the shelf life of tomatoes after harvest.

Today, one of the major global challenges in the agriculture sector is food security as well as ensuring long-term sustainable development. According to the Food and

Agriculture Organization report (FAO, 2008), production of food will need to rise by 70% to feed the ever-increasing global population which will reach nine (9) billion by 2050 according to Kiaya (2014). Crop losses should be given prime concern so as to improve food security, increase farmer's income and stop hunger especially in developing countries (FAO, 2010). While a total of food insecure population continues to be unacceptably high as a result of post-harvest losses on the food journey chain from harvest to consumption due to several factors, it is very imperative to assess and if possible reduce the rate to ensure food sustainability.

Tomato (*Solanum lycopersicum*), belongs to the family Solanaceae which is an extensively grown and consumed staple vegetable fruit in the world, and it is a good source of nutrients such as minerals and vitamins in food consumed by humans (Babalola *et al*, 2010). According to Van der Hoeven, Ronning, Giovannoni, Martin, and Tanksley (2002), Solanaceae is the third main economically grown crop after cereals and legumes and it is the worthiest in terms of vegetable crops and agricultural utility. Tomato forms part of the food consumed in Ghana and it is an important ingredient in Ghanaian dishes during meal preparation and service (Tambo & Gbemu, 2010; Osei *et al*., 2014).

Tomato production over the past few decades was envisaged as one of the key drivers of both rural and urban areas in Ghana through job creation and poverty alleviation (Asare-Bediako *et al.,* 2007; Sugri *et al*., 2013). Following Sugri *et al.* (2013), tomato production in the Upper West Region is noted as an antidote for the widespread unemployment and poverty for the majority of households. In general, food loss does not only reduce the quantity of food produced, but reduces availability, the saleability of wholesome food as well as the accessibility of the food and the effect of these losses impacts greatly on farm income at different locations. Insight of this, Sablani *et*

al. (2006) indicated that food availability increases when there has been a reduction in fresh produce and significant in sustaining agriculture.

Maturation, ripening, and senescence are three clear-cut phases in the life span of vegetables and fruits that have been differentiated by postharvest physiologist. Maturation denotes fruit being ready for harvest (Arah, Amaglo, Kumah, & Ofori, 2015). Matured tomatoes are usually harvested when the plant is fresh and has high moisture content. Tomato farmers and traders in the tropics are confronted with special problems in handling, transportation, and marketing due to the perishability nature of the produce precisely. The storage life of fresh vegetables such as tomatoes depends on the good harvesting practices such as harvesting quality ones (Hurst, 2010; Kitinoja & Gorny, 2009). Fresh tomatoes easily damages and have short storage life if harvested in a fully ripened state.

1.1 Statement of the Problem

In recent times, it has been observed that a lot of young farmers engage in tomato farming in varied scale of production in farming communities in the Upper West Region. Some of these tomato farmers do it on larger scale for commercial purposes whereas others cultivate tomatoes in smaller scale as a side crop in a mixed cropping system. During the major raining season, all of these group of tomato farmers are actively engaged in tomato production both for consumption and for commercial purposes. The major cultivation period which falls within June to October is usually characterised with high production, availability of tomatoes with low market value hence high perishability of the produce. In Ghana, Robinson & Kolavalli (2010) as cited in Yeboah (2011) observed that the tomato production sector has not achieved their potential because of increase rate in perishability of the vegetable, absence of

ready market, nonexistence of a reasonable alternative uses of the vegetable and unreasonable pricing are some of the challenges faced by crop handlers, out-of-date post-harvest practices linked with poor storage facilities constitute the persistent cyclical post-harvest losses of tomatoes

Also during the major production season where tomatoes are readily available and accessible, most of the local women are observed to engage in the production chain as wholesalers and retailers in various markets and communities. The wholesalers usually travel to the farm lands to buy the produce at cheaper prices .The tomato is usually packaged in wooden boxes, woven baskets, basins and plastic buckets. The major means of conveying these produce are tricycles (motor king), cargo tracks (kia), and donkey cart to various market centres for sale to the retailers which mostly get damaged on arrival to the market centres increasing the perishability level of the produce. Most of these farmers and retailers equally have very little or no preservation knowledge or skills to enhance the keeping value of tomatoes to maximised utility. Ajagbe, Oyediran, Omoare & Sofowora (2014) posit that in almost all emerging economies as in the case of Ghana, storage, packaging, transportation, handling and treatments methods are essentially non-existent regarding tomatoes leading to substantial losses of the produce. Most of the retailers have no appropriate storage space, appropriate means of transport, poor road network and readily available market to sell their produce. They are usually dotted in the market with the produce displayed on weak tables, on rags on the floor and in basins exposing the produce to warmth and sunshine (heat). These practices as observed could post serious threat to the quality and quantity of the tomatoes as well as its economic and nutritional value.

However, it appears there is little or no literature on the post-harvest handling practices and challenges facing tomato farmers and retailers in the Upper West

Region hence the study seeks to bring to light the post-harvest handling practices and challenges among tomato farmers and retailers in some selected districts in the Upper West Region.

1.2 Main Objective

The main objective of this study was to assess post-harvest handling practices and challenges among tomato handlers in some selected Districts in the Upper West Region of Ghana.

1.2.1 Specific Objectives

1. To identity the post-harvest handling practices of tomatoes among farmers and retailers in some selected Districts in the Upper West region of Ghana.
2. To examine the causes and ascertain the challenges of post-harvest losses of tomato faced by tomato farmers and retailers in some selected Districts in the Upper West region of Ghana.
3. To assess tomato treatment methods used by tomato farmers and retailers in the selected Districts in the Upper West region of Ghana.

1.3 Research Questions

1. What are the post-harvest handling practices of tomatoes among farmers and retailers in some selected Districts in the Upper West Region of Ghana?
2. What are the causes and challenges of post-harvest loss of tomatoes faced by tomato farmers and retailers in the selected Districts in the Upper West Region of Ghana?

3. What are the common tomato treatment methods used by tomato farmers and retailers in the selected Districts in the Upper West region of Ghana?

1.4 Significance of the Study

The results of the study would be significant to the following group of people;

Data from the study would revealed tomato handling practices by tomato farmers and retailers in the selected districts. This information could help the Ministry of Food and Agriculture to liaise with the Agriculture Extension Officers in the various Municipals and Districts Assembles to organize training programs to equip farmers and retailers with the appropriate handling practices.

Also, data obtained from the study will reveal the marketing needs of tomato farmers and retailers in the region. This will help local government to organize market space and structures for efficient production and sale of tomatoes.

It could also inform Non-Governmental Organizations who have vested interest in tomato production and processing to develop appropriate intervention schemes in the form of provision of irrigation dams and tomato processing factories to boost tomato production all year round and reduce wastage in the upper west region.

The identified causes of post-harvest loss of tomatoes could be reduced as Ministry of Food and Agriculture could collaborate with Agricultural Extension Officers to organize training programs to equip the knowledge and skills of tomato handlers to reduce losses and maximize profit

Consumers will equally stand the chance of enjoying quality tomato produce all year round as a well-structured tomato market will be designed and used to their advantage making the tomato produce readily available and accessible to them.

The results of the study will substantially contribute to knowledge by filling the existing gap in literature regarding the handling practices, causes of post-harvest loss of tomato among tomato farmers and retailers and the challenges confronting them.

1.5 Limitations of the Study

The researcher acknowledged the following as limitations that affected the results of the study:

a. The research was undertaken during the raining season so more tomato farming and retailing communities which were inaccessible were not visited to obtain data. Only communities which were easily accessible by good roads were selected for this study.

b. The number of people (farmers and retailers) whom the questionnaires were administered to also reduced drastically due to the corona virus pandemic (COVID-19), which was prevalent at the time. This therefore, reduced the number of participants in order to prevent infections. The number of Agriculture Extension Officers who were interviewed also reduced since some of them did not want to be interviewed for fear of being infected with the virus (COVID-19).

c. The prevailing health protocols issued by the Government of Ghana at the time of COVID-19 pandemic did not permit the meeting of larger groups of people for focus group discussion which initially was a tool the researcher wished to employ for data collection.

d. Some of the respondents were not educated and hence could neither read nor write. Hence, the questionnaires were interpreted to them by the Agric Extension officers and the researcher. The Agric Extension officers

interpreted that of the farmers to those who could not read and the researcher interpreted that of the retailers to them. This could also affect the results obtained from the study depending on how the interpretation was done.

1.6 Delimitation of the Study

The study identified post-harvest handling practices of tomatoes by both tomato farmers and retailers in four selected Districts in the Upper West region of Ghana. It further discussed the causes of post-harvest loss of tomatoes along the food value chain among tomato handlers and the challenges of post–harvest losses confronting tomatoes farmers and retailers in the study area. The study also assessed the common treatment methods that are mostly used by tomato farmers and retailers to reduce or slow down the perishability level of the tomato produce by its handlers.

1.7 Organization of the Study

The research is organized in five chapters. The introductory chapter which is chapter one presented the introduction, statement of problem, objectives of the study, research questions, limitation, delimitation and organization of the study. Chapter two covered the review of related literature. It highlighted the conceptual framework, the concept of post-harvest loss of food, tomato and its varieties, causes of post–harvest loss of fresh fruits and vegetables (tomatoes), marketing of tomato, harvesting as a post–harvest handling practice of tomatoes, treatment methods for tomatoes to reduce post–harvest loss, and the concept of value chain in tomato production.

Chapter three (3) describes the methods and methodology used in the study. It discussed the research design, population, sample size and sampling technique, research instrumentation, data collecting procedure and data analysis.

Chapter four (4) captured results and discussions whereas the final chapter which is chapter five presented the summary, conclusions and recommendations.

1.8 Definition of Terms and Acronyms

Loss: It is the crop damaged cost incurred by crop handlers.

Post-harvest: They are the activities that take place after the harvesting of crops.

Post-harvest Loss: It is the crop damaged cost incurred after harvesting of crops by crop handlers.

Tomato handlers: They are individuals or groups who manage the production and sales of tomatoes. The handlers may include farmers, retailers, wholesalers as well as consumers.

Tomato Farmers: They are individuals or groups who cultivate tomatoes.

Tomato Retailers: They are individuals or groups who market tomatoes

1.9 Summary

This chapter deals with post-harvest handling practices of tomatoes among farmers and retailers, causes and challenges of post-harvest loss facing tomato farmers and retailers and the treatment methods employed to reduce loss of tomatoes in the upper west region. The section generally looked at the several post-harvest practices adopted by international and in particular various tomato-growing areas in Ghana and compare it to the very tomato handling and treatment methods mostly employed by local tomato growers and retailers within the study area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Basic Concepts of Post–Harvest Loss of Vegetable Crops

Losses are a quantifiable decrease in food stuffs and may distress either the quality or quantity or usually both. This ascendance is based on the fact that freshly harvested agrarian produce is a living creature which breathes and goes through modifications during post–harvest handling.

Post-harvest losses occur when unsuitable harvesting method is practised coupled with the ways by which produce are transported, stored and marketed. This is because, the losses basically occur during harvesting and when fresh fruits and vegetables are being transported from one source of production to the sales point. Post-harvest losses denote produce perishability in the food supply chain as observed by Parfitt, Barthel, & Macnaughton (2010).

Post-harvest losses occur when inappropriate harvesting system takes place, and the manner events arise in the course of storing and transporting produce to the market centres or to the final consumers. Post-harvest losses are the fundamental damages that happen during harvesting and after the produce are being transported from its production point to the final sales point or to the final consumer. Post-harvest loss is synonymous to food wastage in the food supply chain (Partitt *et al.* 2010). Post-harvest losses can be grouped in two namely, quantitative and qualitative loss (Anaba, 2018). Qualitative loss discusses losses in the nutritional and caloric value, damage of acceptability by consumers of the product and forfeiture of edibility relative to the commodity. Qualitative loss assesses the reduction in nutrition level and unusual changes in appearance of food. Quantitative loss is explained as the loss of genuine product leading to a reduction in the amount available of a product (Egyir, Sarpong, &

Obeng-Ofori, 2008; Aulakh, Regmi, Fulton & Alexander, 2013). Quantitative loss deals with the reduction in volume (Buzby & Hyman, 2012). Food waste refers to consumable foods that are lost as a result of thoughtful and unthoughtful postures of human actions.

Kader (2013) posits that post–harvest loss is the deprivation in quantity and quality of a crop from the unset of harvest to the point of consumption. He further explained that quality injuries comprise those that distress the nutrient or caloric constituents, the satisfactoriness and the edibility of a given farm produce, whereas quantity losses denote those that lead to the loss of the sum of volume of the product. The commonest in developing countries is the loss of quantity than loss of quality (Kitinoja & Gorny, 2010). Devkota, Dhakal, Gautam, & Dutta, (2014) contended that post–harvest loss may well be elucidated as the qualitative and quantitative damage of agrarian produce at any period of time within the post–harvest value chain that take account of the adjustment in edibility and healthiness. These injuries have a tendency to become higher in countries where the demand for diet is greater. It is estimated that foods such as tomatoes, sweet potatoes, banana and citrus fruits sometimes record losses as high as fifty (50%) percent (FAO, 2010). This means more than half of what is cultivated certainly does not get to the consumer for which reason it was, and the attempt and the money needed to produce it all get lost forever (Mujib, Naushad & Inayatullah, 2007). They indicated that issues that account for post–harvest produce loss consist of ineffective pre-harvest measure, adoption of inappropriate production methods (variations in minimal shelf life, unbalance utilization of nutrients, insects, pest and disease attacks and abiotic stresses), misapplication of pre–harvest acclaimed treatments techniques, harvesting at inappropriate stages, and lack of proper care of harvest, unremoved field heat, damping crops, humidity condensation that causes

pathogens invasion, packaging in bulk without sorting and grading, inadequate transportation and storage methods, distance and time from conveying produce to market centres for further redistribution. The losses incurred lead to minimal return to farmers, processors and retailers (Kader, 2013).

2.2 Tomato and its varieties (Solanum lycopersicum)

According to Knapp (2002), tomato, with its botanical name *Solanum lycopersicum* belongs to the Solanaceae family known as Nightshades, which include more than 3000 species. Some of the crops in the Nightshade family cover tobacco and vegetables such as pepper, potato, eggplants. It originated from areas around Chile, Bolivia, Ecuador, Colombia and Peru (Peralta, Knapp & Spooner, 2007) with the latter becoming the centre of diversity, and Mexico, the site of domestication (Robertson & Labate, 2007). Soyk, Lemmon, Oved, Fisher, Liberatore, Park & Van Eck (2017) opined that tomatoes were initially pea-sized berries but due to domesticated and plant breeding activation, the plant has resulted in increased fruit. This assertion is further reinforced by Gould (1992) who reported that early tomatoes were perhaps small-fruited because they were mostly like the small-fruited *cerasiforme* variety cultivated by the Aztecs.

The fruit is a typically red edible fruit having multiple leaves with the whole leaf connected to the stem by the petiole. The leaves are attached to the rachis of the leaf by the petiole with various kinds of the leaflets on this leaf being compound additionally (Rost, 1996). Tomato likewise has flawless flowers gathered in compound inflorescences known as a cyme. For each inflorescence that customarily consist of 4 to 8 flowers, and every plant may yield as more succeeding inflorescences in the course of its life cycle (Tigchelaar, 1986). The time yellow flowers of tomatoes

have five pointy lobes on the corolla. Tomato fruits are usually green when unripe and develop deep red colour when ripe.

Sacco, Frusciante, Lorito & Di Matteo (2008) asserted that there are two main types of tomato, and they include the Hybrid and Open pollinated tomatoes of which other scholars classify them as groups. Within these two groups, there are countless varieties. The Hybrid tomatoes are crossed between two different tomatoes often with positive and negative parts (Sacco, Frusciante, Lorito, & Di Matteo (2008). The positive part carries the desired traits of either parent such as size of fruit, resistance to some diseases and even odour. The negative part is the section that could revert to either of the parent plant or would become sterile and will not produce seeds at all.

2.3 Causes of Post–harvest Lost of Fresh Fruits and Vegetables (Tomatoes)

Parnell, Suslow, & Harris (2004) stated that tomato (Solanum Iycopersicum) is botanically classified as a fruit (berry) and it is generally regarded as a vegetable. Tomato production has increased to nearly 163 million tons over the past decade as a result of its economic and nutritious value (FAOSTAT, 2014) due to its lycopene content, which is some sort of carotenoid with antioxidant properties (Arab & Steck, 2000).

According to FAOSTAT (2014), second to Egypt, Nigeria is the major producer of tomatoes in Africa with an annual production estimate of 1.56 million metric tons. The vegetable has an average shelf life of one week, since it is a perishable crop, whose quality can be maintained at ambient temperature for the purposes of preservation and storage. The vegetable is mostly harvested during periods of high moisture content and freshness (Ayandiji, Adeniyi, & Omidiji (2011). The tomato fruit after harvesting continues to respires and live as a living tissue until consumption

or deterioration takes place. Its quality is determined mainly by colour, texture, flavour and nutritional quality (Kader & Rolle, 2004).

The actual cause of post–harvest loss of fresh fruits and vegetables are many and commodity specific. According to Chun–Ta Wi (2010), the main causes of product deterioration are continuous metabolism and growth, water loss, physiological disorders, mechanical damage and pathological breakdown. In a related development, Hailu & Derbew (2015) explained that the causes of food losses vary between developed and developing countries. Citing Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck (2011), he indicated that the causes of food loss in developed countries mainly relate to consumer behaviour as well as quality standards. However, the causes of food loss in developing countries is mainly connected to financial, -managerial and technical limitations in harvesting techniques, storage conditions, infrastructure, packaging and marketing systems. Kitinoja & Gorny (2010) is also of the view that physical and quality losses of foods are mainly due to poor temperature management, use of poor-quality packaging, rough handling, and a general lack of education regarding the needs for maintaining quality and safety of perishables at the producers, wholesale and retail level.

Anaba (2018) also attributed the cause of post-harvest loss of tomato to overcrowding and packing of the produce for a longer period of time. Addo, Osei, Mochiah, Bonsu, Choi & Kim (2015) have also associated the cause of post-harvest loss of tomato on delay harvesting and pest and disease attack of the produce.

In a related development, Hailu & Derbew (2015) included poor temperature management, mechanical injury, microbial action and poor packaging as some of the major causes of post – harvest loss of fresh fruit and vegetables. Another school of taught opined that causes of post – harvest loss in fruits and vegetables are related to

issues bordering harvesting, storage, transportation, improper packaging and consumer's waste (Elik, Yanik, Istanbullu, Guzelsoy, Yavuz & Gogus (2019). It is obvious that the loss of fresh fruits and vegetables in the post – harvest supply chain is common in the developed and developing countries and this has been a trait to the continuous supply of food to mankind. Finding remedies to this menace will do better than harm to mankind.

2.4 Marketing of Tomato

Tomato (Solanum Iycopersicum) has become an important cash and industrial crop in many parts of the world not only because of its economic importance but also its nutritional value to human diet and subsequent importance in human health (Willcox, Catignani & Lazarus, (2003) Tomato is a short duration crop according to Nicola, Tibaldi, & Fontana (2009) which requires relatively cool to dry climate for good yield. Sacco, Frusciante, Lorito, & Di Matteo (2008) claim that other varieties of tomato are sold worldwide than any other fruit.

Ghana imports tomatoes from neighbouring countries like Burkina Faso from the Northern belt since its demand is more than supply due to post–harvest losses. Tomato is a vegetables crop with a greater number of varieties sold worldwide (Sacco *et al.* 2008). The Availability of the wide range of varieties give farmers and consumers the opportunity to choose the desire variety for planting and consumption MOFA (2008) Cited in Anaba (2018).

The production system of tomatoes truncates during the harvesting stage and nevertheless starts with linked of significant activities that ensure that consumers of the vegetable attain maximum satisfaction (Anaba, 2018). Orzolek, Bogash, Harsh, Lynn, Kime, Jayson & Harper (2006) conceded that the production of tomatoes is that

of a difficult one requiring intensity of labour to the point that the vegetable must be harvested in matured vine-ripe state in order to prevent the produce from becoming overly ripe for easy transportation to the market centres and further to the final consumer.

Post–harvest losses of tomato are losses faced by the producers, processors, distributors, retailers as well as exporters in handling the produce after it has been harvested until it gets to the final consumers. Tomatoes like any other vegetables have high moisture content and this facilitate spoilage faster. Harvesting during maturity especially when partially ripped and at the right time during the early hours of the morning or late evening will help reduce field heat and slows down the rate of spoilage.

An empirical study by Ayandiji *et al. (*2011) revealed that the usage of vehicular trucks as means of transportation are not effective mechanisms of preventing postharvest losses compared to the transportation by means of motorcycle, bicycle or goods carried by head-load, and this denotes that some methods of tomato transportation reduce quantity losses to the lowest degree. Per this empirical study also, it is established that the quantity loss of fresh fruit increases as transportation distance of the produce also increases due to overcrowding and over-packing of the produce for longer period of time. Another cause of post-harvest loss of tomatoes is as a result of delay in transporting the vegetable to the market centres or to the final consumer. This phenomenon is most often occasioned by the bad nature of roads linking farms to the market centres. The delay in produce transportation leads to over-fruit ripening and softening making it prone to mechanical damage and fermentation with age. Aidoo, Danfoku & Mensah (2014) as cited in Agana (2018) observed that

gender of female as in the case of female and farm size were comparatively and really account for post-harvest loss of tomatoes within the enclave of Ghana.

Kader (2005); Adeoye, Odeleye, Babalola, & Afolayan, (2009) contended that the main causes of post–harvest losses in tomatoes comprise mechanical damage, physical deterioration, biological (post-harvest diseases and insect pests), rodents and birds. Such losses turn to be comparatively lesser for vegetables likened to injuries as a result of jagged handling, improper packaging, and quality injuries occasioned by humid pressure as explained by World Food Logistic Organization (2010). In a related development, Emana, Afari-Sefa, Nenguwo, Ayana, Kebede, & Mohammed (2017) added that post-harvest losses of tomato in some cases can be attributed to socio economic and established causes such as insufficient selling information and support schemes, unsuitable transportation services, unfavourable government programmes, incapability of applying regulations and legislation, nonexistence of fitting tools and equipment, technical deficiency and poor maintenance practices for available facilities and infrastructure. FAO (2011) however elaborated that post-harvest losses varies significantly with produce, production sites and periods in addition to the magnitude of improvement in infrastructure and technology for post-harvest management issues and marketing systems.

Arah (2014) and Arah *et al.* (2015) in their study agreed that the causes of post-harvest loss of tomatoes can be classified into two main clusters. They include on farm and off–farm causes. On farm factors occur while the produce is still in the farm whereas off–farm causes occur after the product is harvested and ready to be used or marketed.

Orzolek *et al*. (2006) observed that the basic marketing options accessible to the tomato farmer include general markets, enterprises, local vendors, roadside stands and

treatment companies. According to the scholar, marketing cooperatives largely utilizes a daily-assembled cost and price that extent price variation to all partaking producers. More importantly, new and treated produce can be sold on the farm, locally or through wholesale or retail setups, or by exports to foreign nations. In determining the ways to market one's new or processed crop, each post-harvest handling stride made offers a chance to earn extra profits according to Kitinoja (2004).

Ellis, Olympio, Mensah, Adu-Amankwa, Tetteh, (1998) reported that in Ghana, farmers most often do not practise on-farm and off-farm storage of tomatoes, therefore, the main post-harvest challenges facing them was the need for permanent buying centres and the maintenance of the unit price for the box of tomato.

2.4.1 On–farm causes of Post–harvest Losses in Tomatoes

The issue of non-adherence to approved guidelines on harvesting and post-harvesting approaches is one of the leading causes of tomato perishability in developing economies like Ghana. Again, non-adherence to makers' directions on the usage of their products leading to in their extensive misuse causes post-harvest losses (Ellis *et al*. 1998).

Kodjogbe, Pali, Agyemang, Asamoah, Kouame, Gnonlonfin, Hell & Coulibaly (2010) explained the leading causes of post-harvest losses as those having their origins at the producer level to the usage of indigenous seeds/self-propagated seeds, disproportionate usage of manures and pesticide residues, inappropriate reaping practices and improper handling schemes that cause crop losses in the course of transportation and storage.

According to Arah (2014) and Arah *et al*. (2015), on-farm causes of tomato losses include:

Improper harvesting periods;

Nonexistence of suitable harvesting containers;

Too much field heats and non-existence of on–farm strong facilities;

Unsuitable packaging materials and

Ineffective field sanitation.

2.4.2 Off–farm causes of Post-harvest losses of Tomatoes

The illiteracy of traders is a challenging factor in making them to comprehend and stop some practices that lead to improper handling which distresses the conservancy of the produce. According to Kodjogbe *et al.* (2010), the main causes of post-harvest losses of tomatoes at the producer level can also be attributed to the use of local seeds/auto-propagated seeds, excessive use of fertilizers and pesticides (pesticide residues), poor harvesting practices and poor handling (practices, packaging, etc.), transportation and other storage factors.

Arah *et al*. (2015) posit that off–farm causes of tomato loss in Africa include:

Lack of good access roads (Babatola *et al.* 2008).

Inappropriate mode of transport (Idah, *et al.* 2007).

Lack of processing equipment and factories (Ayeetey, 2006)

Lack of reliable market (Aidoo *et al*. 2014)

Lack of ready market (Aidoo *et al*. 2014)

2.5 Post–Harvest Handling Practices of Tomatoes

Post-harvest handling practices of tomatoes to a very larger extent can have a terrible consequence on the post-harvest quality and shelf life of the produce. Irregular handling in the course of harvesting and after harvesting of tomatoes can cause mechanical injuries with severe adverse effect on the post-harvest quality and shelf life of the harvested produce (Arah *et al.* 2015).

In times past, rural farmers and retailers depended on native or local ideas for improving farming and marketing systems. Such ideas being native or local denote the dexterity and experience acquired by verbalized traditions and practices for several generations as observed by Nnenna (2011). Attainment of such aboriginal skillfulness by indigenous farmers and retailers has barely helped in improving agrarian yield (Nnenna, 2011). This practice of adopting primitive skills for improved farming and marketing of tomato is generally evident in developing countries such as Ghana because storage, packaging, transport and handling systems are realistically non-existent in relation to perishable crops, so this results in substantial losses of produce. Besides, undignified post-harvest sanitation, improper packaging systems and mechanical damage in course of harvesting, handling and transportation resulting from vibration by undulation and irregularities on the road according to Idah *et al.* (2007), further enhance wastage. It is worrying to indicate that so much is being invested in planting tomato; therefore, a lot of resources expended on irrigating, fertilizing and crop safety management are only to be fruitless few days after harvest. Post–harvest loss of tomato occurs due to immaturity, over–ripening, mechanical damage, and decay (Esguerra & Rolle, 2018). They added that these losses can be attributed to poor harvesting methods, irregular handling, inappropriate packaging and unsuitable transport conditions.

Babalola & Agbola (2008) concluded that post-harvest losses of tomato have been regarded as elements of food problem in most developing economies like Ghana.

Ajagbe, Oyediran, Omoare, & Sofowora, (2014) observed that information concerning post-harvest handling of tomato is well circulated among tomato farmers and retailers themselves. The reason being that most of these tomato handlers obtain their information on new variability, its physiognomies and benefits, period of planting and harvesting, selling, use and post-harvest practices from their fellow farmers and retailers, since farmers and retail unions play significant roles in obtaining information on tomato post-harvest handling practices among their members. Ajagbe *et al*. (2014) also established that some tomato handlers obtain their post-harvest handling practices information from their friends and neighbours. These results are reflected in the observations of Adekunle, Omoare & Oyediran (2014) that farmers depend on data from farmers', retailers' union and fellow farmers, with only a handful relying on radio/television, and Agric extension officers, which is pretty unfavorable to post-harvest practices of tomato.

Ajagbe *et al.* (2014) believed that tomato handlers rather should obtain agricultural information for improved farming and marketing systems from credible sources such as extension officers, public libraries, radio, television, film shows, agricultural pamphlets, state and local government agricultural agencies. This is because, appropriate post–harvest handling of tomatoes is important in maintaining quality and ensuring safety while being brought to the consumer on time. This also help meet buyer`s specification and trade requirements.

With ever changing consumer taste and lifestyle, more attention is placed on post-harvest handling of tomatoes to fulfil their request for enhanced quality and safe produce. Arah et al. (2016) postulate that the physical handling can pose a severe

effect on the post–harvest quality and shelf life of so many fruits and vegetables. They elaborated that jagged handling during and after harvesting can affect the produce by causing mechanical injuries that can disturb the post–harvest quality and shelf life of harvested crops like tomatoes.

Esguerra *et al*. (2018) opined that the characteristics of the tomato fruit and its handling practices affect its post–harvest life. Improper handling may cause wounds that pave way for decay causing agents. Wounds are also pathways to loss of water in a produce loss and can further accelerate the maturing course, they added. Inappropriate handling such as stalking the produce in bamboo baskets and sitting on stalked tomatoes during transport causes damage to the fruit. According to Ajagbe *et al*. (2014), there are different methods of packaging tomato. Tomato farmers and retailers use woven baskets of 25-75kg and perforated plastics to package their produce. It is pertinent to note that in most rural communities where tomatoes are mostly grown, woven baskets of different dimensions are regarded as ideal containers for packing tomatoes since they are cheap, have adequate holes for aeration, less difficult to carry, offer better care from mechanical injury, and suitable for retailing (Ajagbe *et al*. 2014).

It is important for tomato handlers to familiarize themselves with suitable post-harvest handling practices required to preserve the quality and prolong the shelf life of harvested tomatoes for producers in developing economies. Some of the handling practices comprise Reaping

Pre-cooling

Cleaning and disinfecting

Sorting and grading, packaging

Transportation and storage as outlined by Arah *et al.* (2016).

2.5.1 Harvesting as a Post–harvest Handling Practice of Tomatoes

The physiological maturity of tomato at harvest has an important effect on post–harvest quality of the produce (Beckles, 2012), because the harvesting time of tomatoes is a crucial stage for attaining its greatest quality. According to the post-harvest physiologists, the lifespan of fruits and vegetables can be classified in three stage such as Maturation, ripening and senescence (Esguerra *et al.* 2018). The FAO (2008) explain maturation as an indicative period for the harvesting of the produce, and also, the stage during which the edible part of it is fully developed in size, although it might not be ready for immediate consumption. With respect to tomatoes, Arah *et al*. (2015) asserted that the produce can be harvested in either matured green, partially ripe, or ripe state.

Harvesting them at the mature stage will give enough time for ripening and senescence to take place especially for producers targeting distant markets, and will prevent or reduce mechanical injuries in the course of harvesting. This claim is supported by Orzolek, Bogash, Harsh, Lynn, Kime, Jayson & Harper (2006) who state that harvesting of tomato is a labour-intensive venture requiring its harvesting in matured green stage to prevent overripe in the course of transportation to long distanced market centres.

Ripening precedes maturation rendering the crop eatable as indicated by taste. Senescence is the final stage, considered as natural deprivation of the fruit or vegetable as in loss of texture, flavour, colour etc.

The time of picking is a vital factor in post-harvest practices in tomato production. Ajagbe *et al.* (2014) posit that 62% of tomato farmers picked their tomatoes in the evening to be transported all night. They do so because they want to reduce perishability due to the day-time high temperature under which the produce will be

transported, the long distance between farms and markets in urban centres coupled with the poor nature of roads. Farmers and retailers as a result of this pick their produce to make them arranged for transportation and accessible for sale in the markets the next day. Nonetheless, few of the tomato farmers and retailers harvest their tomato produce in the morning because they transport their tomato produce to the local and nearby markets all by themselves. These observations regarding the time for tomato harvesting by these handlers are consistent with the discoveries of Muhammad *et al.* (2012) who found that reaping of fruits and vegetables should be carried out in the course of the cool part of the day.

Regrettably, most growers in developing economies (specifically those in rural communities) reap tomatoes whenever they are somewhat or completely ripened. Completely ripened tomatoes are vulnerable to mechanical damages in the course of harvesting occasioning their shorter shelf life (Arah *et al*. 2016). The usage of harvesting and packaging containers that have sharp edges must not be given prominence so as to avert bruising and puncturing of the crops. Fruits and vegetables should also be harvested early in the morning or late in the evening to avoid excessive field heat generation.

2.5.2 Pre-cooling after harvest as a post–harvest handling practice

Ilyas (2010) and Bachman & Earles (2000) identified pre–cooling as the initial stage that is appropriate for post-harvest management of tomato, since the field warmth of a newly reaped crop, as in the case of tomato (heat that is contained in the product emitted by the sun and warm temperature is commonly high) ought to be quickly eliminated before they are shipped, processed or stored. Extreme field warmth accelerates undesirable increase in metabolic actions, and so early cooling after

harvest is therefore important. The appropriate temperature range of about 13–20^{0}C for the handling of tomato can be achieved either at dawn or latter part of evening. (Kader; 1984, Risse, Miller & McDonald; 1985, Arah *et al*., 2016).

Pre-cooling lessens the effect of microbial action, metabolic activity, and respiration level and ethylene production and at the same time reducing the ripening rate, water loss and decay leading to the preservation of quality and extension of shelf life of harvested tomatoes (Shahi, Lohani, Chand & Singh, 2012).

Contingent on the sort of fruits and vegetables, various pre-cooling techniques exist. Ilyas (2010) outlined cooling of room, compulsory cooling, water cooling, top or liquid icing and vacuum cooling as the various pre-cooling types. In Africa and for that matter Ghana, tomato producers gather their harvested produce under tree shade in a bid to minimize field heat, even though it is an effective and reliable means of attaining reduced heat of harvested tomato as being suggested by Arah *et al.* (2015), the acceptance of a simple on-farm setup like a small hut built of thatch can be very beneficial in pre-cooling of harvested tomatoes.

2.5.3 Cleaning or disinfecting as a Post–Harvest handling practice

Good hygiene is of great concern to all handlers of tomatoes not only because of post-harvest infections but also to prevent the occurrence of food borne sicknesses that can be conveyed to consumers. Washing and disinfecting is required to clean produce which have acquired latex stains from injuries resulting from bad harvesting and handling. This can be further elaborated that clean water should be used and that the tomato produce should not be washed in recirculated water because it can easily become heavily contaminated with decay organisms leading to rotten of the washed product. It is beneficial to add hypochlorite or chlorine to the washing water of fresh

fruits and vegetables to treat them to reduce microbial load before consumption. This however is mostly is recommended for only large-scale operations (Wahome, 2019).

On the contrary, cleaning or disinfecting tomatoes after harvest is an uncommon techniques for many handlers of tomatoes in developing economies like those in Africa. (Arah *et al.* 2016). This technique may be ascribed to either non-existence of portable water at the production spots or absolute witlessness of the technique.

Elaborating further, Arah *et al.* (2016) indicated that disinfectants can be used for either washing or precooling in places where water is not a constraint, to reduce both post-harvest losses and food borne diseases in fruits and vegetables. Tomatoes can be dipped in thiabendazole solution to reduce microbial load on the fruit (Batu & Thompson, 1995). Outbreak of salmonella and E coil are often as a result of contamination from animal waste used as a source of fertilizer. It is therefore important that all organic fruits and vegetables are thoroughly washed before sending to the market.

2.5.4 Sorting and Grading

Vegetables that are produced and sold in modern markets should be sorted and graded based on their size, colour and texture. Sorting is the elimination of rotten, spoilt or unhealthy fruits and vegetables from the healthy and hygienic ones (Arjenaki *et al*. 2013). The damaged or diseased fruit can produce ethylene in considerable amounts which can contaminate the healthy ones close by.

Grading is the procedure for grouping fruits and vegetables on the basis of size, colour, and phase of maturity or extent of ripening. Sorting limits the spread of infectious micro – organisms from bad fruits to other healthy fruits during post – harvest handling of tomatoes whereas grading assists handlers to group fruits and

vegetables within shared parameters and this provides stress-free handling (Arah *et a*l., 2016). Arah *et a*l. (2016) further added that there are four basic steps involved in primary selection during sorting and grading. They involve the removal of over matured, too small, severely damaged and deformed or rotten ones.

Good class and harmless tomato fruits are matured, cleaned, well–shaped, free from pests and disease destruction, free from mechanical injury like cuts, abrasion and punctures, free from microbial, chemical and physical contamination (Esguerra *et a*l., 2018). Classifiers must exercise good individual cleanliness like washing of hands with soap and clean water before handling produce. The workers should also be in a comfortable position during sorting since uncomfortable position can lead to fatigue and hence in appropriate sorting procedures.

2.5.5 Transportation

The main objective in transport is to ensure that produce attain top quality condition to the final market or consumer. Tomatoes usually under take three transport phases, farm to collection centre or packing shed, packing shed to wholesale market and from the wholesale market to retail market (Esguerra *et al.* 2018). In most developing countries, transporting harvested tomatoes from the point of production to distribution centres is hampered by poor road network. Transporting reaped tomatoes to the market on a bad road and non-existence of proper transportation systems like chilled vans remain the greatest challenge to producers and retailers (Abimbola, 2014). This challenge according to Kader (1986); Arah *et al.* (2016), causes needless interruptions in conveying the produce to the market. Any delay between the reaping and eating of tomatoes can lead to potential losses. Producers invariably use any obtainable mode of transport to convey their produce to marketing centres without bearing in mind its

suitability in order to avoid delays which increases perishability rate. Some of these mode of transport are tricycle, human labour, animals, public transport, hired trucks, buses, lorries, articulated trucks and pick–up vans (Esguerra *et al.* 2018; Getinet *et al*. 2011). Similar findings by Ajagbe *et al*. (2014) revealed that tomato farmers constantly conveyed their produce to marketing centres by using pick-up van, motorcycles and trucks, with a handful of them using their cars to convey the produce to markets. Bicycle and head are not commonly used to convey tomatoes to the market. This observation by Ajagbe *et al.* (2014) is supported by the assertion of Muhammad *et al*. (2012) that transportation of tomatoes ought to be carried out in a well-ventilated vehicle with a cover at the top to avoid direct sunlight, safety from rainfall and other hazards. Therefore, the use of these inappropriate transport systems facilitates post–harvest loss in fruits and vegetables.

In the course of transportation, the produce should be properly packaged and stacked to avoid excessive movement and vibration (Hurst, 2010; Idah *et al.* 2007). Using unsuitable packaging can cause undesirable loss in fruits and vegetables during transport. That is severe bruising and other types of mechanical injury. The produce is susceptible to physical or chemical damages as well as microbial contamination during transport. It is therefore important a comprehensive food safety and food quality program is given adequate attention to the management of the transportation environment to avoid undue losses. Loading and unloading should be as careful as possible, transit time should also be short, the product should be well protected in relation to its sustainability to physical injuries, avoid over heating during transport, adequate ventilation and air supply should be provided and if possible, transport vehicle should not stop under the sun and the produce protected with a cover.

2.6 Treatment Methods for Tomatoes to Reduce Post–Harvest Loss

After harvesting, the tomato fruit still remains a living tissue and performs all functions of a normal living tissue (Swetha & Banothu, 2018). In order to maintain quality, there are some post–harvest treatment methods that have to be observed to achieve these goals. Swetha & Banothu (2018) outlined chemical, refrigeration, heat treatment modified atmosphere packaging (MAP), edible coating and 1 – methylpropane (1 – MCP), chlorinated water (HIPO), low or high temperature and ultrasounds as alternative post – harvest preservation treatment. The application of these emerging / innovative techniques and treatments and their effects to preserve tomato quality and attain the shelf life of the fruit is paramount. Similarly, Arah *et al.* (2016) identified refrigerator storage, post – harvest heat treatment of tomatoes, modified atmosphere packaging (MAP), Calcium chloride application ($Cacl_2$) and 1 – Methylpropane (1 – MCP) as the post – harvest treatment methods for tomatoes.

Temperature controlling is an important means of enhancing and extending the shelf life of tomatoes. A lot of the physiological, bio–chemical and microbiological actions causing spoilage of produce quality are principally reliant on temperature. In a related development, Mahajan, Caleb, Singh, Watkins & Geyer (2014) posit that various post–harvest treatments; physical, chemical and gaseous treatment can be applied to maintain the fresh – like quality with high nutritional value and meet safety standards of fresh produce. These post–harvest treatment methods should be typically combined with appropriate management of storage temperatures.

According to Mahajan *et al.* (2014), current status of post–harvest treatment and emerging technologies that can be used to maintain quality and reduce wastage are categorized into three as:

a. **Physical Treatment:** Treatments methods under this include; Heat treatment which includes dipping the produce into hot water, saturated water vapour heat, hot dry air and hot water rinse with bruising. Heat treatment is an alternative to chemical treatment and it has a beneficial effect of reducing chilling injury and also delaying the ripening processes by inactivation of derivative enzymes.

b. **Edible coatings:** These are tinny coatings of external layers that are applied to the food surface of new produce to boost the waxy cuticle or a replacement for natural obstacles where the produce cuticles have been detached.

The application of enable coating on new fruits and vegetable offers a partial fence to the roaming of dampness on the surface of the produce, thus reducing moisture loss in the course of post–harvest storage. A gas obstruction establishes an adjusted atmosphere around the product to slow down respiration, senescence and enzymatic oxidation and preserve its colour and texture (Mahajan *et al.* 2014). Edible coating includes chitosan, Aloe Vera, Polyvinyl acetate, mineral oils, and cellulose and protein base coatings.

iii. **Irradiation:** This exposes food to radiant energy from y ray and electron beams high-energy molecular bonds including the DNA of living organisms. Irradiation presents effective post–harvest treatment for destroying bacteria, moulds and yeast which cause food spoilage but not suitable for fresh produce e.g. treating fruit and vegetables because they can cause sensory defects (visual, texture and flavour) and or accelerated senescence due to irreparable damage to DNA and proteins.

c. Chemical treatments: Chemically, sulphur dioxides, Nitric oxide and antimicrobial and anti – browning agents can be used to heat fresh produce

and reduce post – harvest loss. Chemical based agents include chlorine-based solution, peroxyacetic acid (PAA) organic acids, hydrogen peroxide (H_2O_2) and electrolyzed water (Artes *et al*. 2009). However, the efficacy of chlorine – based solution is dependent on the levels of chlorine used. High levels may cause taste and colour defect on treated products.

d. **Gaseous treatment:** These include the ozone, ethylene 1 – methylcyclopropene and controlled atmosphere storage.

Other post-harvest treatment methods that have the potential of enhancing the shelf life and maintain its quality are refrigeration storage, post-harvest heat treatment, modified Atmosphere packaging (MAP), 1-Methylcyclopropene (1-MCP) and Calcium Chloride (CaCl2) application.

Refrigeration Storage

Refrigeration storage of tomatoes is one of the most effective means of preserving the quality of tomatoes for a couple of days (Batu *et al*. 1998). In fact, low temperature storage of tomato like other fruits and vegetable can preserve its non-appearance quality features such as texture, nutrition, aroma, and flavour (Paul, 1999). Tomato handlers in most cases have adopted the used of the refrigeration storage method for preserving tomatoes with the sole aim of extending its shelf life. Nevertheless, tomatoes like other fruits and vegetables that are produced in tropics are delicate to freezing damage when they are kept lower than their critical temperature of 10∘C (Raison & Lyons, 1986). This deficiency of the refrigeration storage method was described by Lee, Kim & Chung, (2008); Babitha, Ninganur, Chetti, Jirali & Harlapur, (2010). Explaining further, they indicated that low temperatures from refrigeration storage caused freezing injuries that lead to in uneven ripening, and

fungal infestation of stored tomatoes suggesting that the refrigeration storage method may not necessarily be the most effective approaches for storing tomatoes for several days. Another set-back in respect of the use of refrigeration for handling tomato in most recent times is its huge initial associated cost to most tomato handlers. On the other hand, in circumstances where tomato handlers can afford the cost of refrigeration storage and a situation where temperature regulation is possible, temperatures of about 10–15∘C should be maintained to prevent freezing injuries (Castro et al., 2005). Regardless of the huge cost of refrigeration storage method, it is essential to regulate storage temperatures and relative humidity in the course of storage, since these boundaries are the main reasons for deterioration in tomatoes.

Post-harvest Heat Treatment

Post-harvest heat treatment has become a very way effective way of minimizing the prevalence of freezing injuries in temperature-induced fruits and vegetables of tropical source like tomatoes. Treatment method that uses hot air and heated water is one of the approaches that can be used to minimize freezing injuries on mangoes, oranges and tomatoes. It is believed that heat treatment of tomato fruit at temperatures between 37–42^{0}C prior to cold storage can slow down ripening and at the same time boost pathogenic resistance when in storage (Akbudak *et al*. 2008) and it does not improve or change the quality traits of tomatoes prior to storage. In situations where refrigeration storage is possible, postharvest heat treatment of tomatoes can be used in conjunction with refrigeration storage in extending shelf life of harvested tomatoes.

Modified Atmosphere packaging (MAP)

This method embodies a packaging system of utilizing specialised resources in packaging products in a prearranged configuration of gases which are principally

oxygen (O2) and carbon dioxide (CO2) after which there is no dynamic effort of altering the storage space (Beckles, 2012). The packaging constituents used in MAP permit for circulation of gases through them till a stable equilibrium is attained between the external gases and those inside the package. The most usually used MAP resources are polyethylene terephthalate (PET), low density polyethylene (LDP), high density polyethylene (HDP), polyvinyl chloride (PVC), polypropylene, polystyrene and other chemically altered byproducts (Beckles, 2012; Sandhya, 2010; Art´es *et al.* 2006; De Wild, Otma & Peppelenbos, 2003). One advantage of using MAP is not only to provide an altered air space to regulate ripening (Kader & Watkins, 2000), but also curtailing water loss in stored products lessening mechanical injuries, and improving better cleanliness that leads to the reduction in the spread of food-borne diseases (Cantwell, Nie & Hong, 2009; Kader *et al.* 2000). MAP produces water drenched or near-saturated air space around tomatoes that minimizes water loss and shrinkage (Batu *et al*. 1998). Loss of water and successive shrinking of tomatoes in tropical areas are one of the causes of their spoilage. Fruit shrinkage may become apparent with minimum amount of moisture loss. The application of MAP by tomatoes handlers in developing countries will consequently avert or minimize the problem of water loss in harvested tomatoes. On the reverse, if this method is not used, the upholding of extremely high level of relative humidity inside the package can lead to moisture condensation on the produce that will produce conducive environment favourable for pathogenic activities that will occasion fruit deterioration (Suparlan & Itoh, 2003). Tomato handlers must therefore be skilled in the appropriate use of MAP for tomatoes to avert humidity concentration that will lead to fruit spoilage.

a. 1-Methylcyclopropene (1-MCP)

The use of 1-methylcyclopropene (1-MCP) has been acknowledged to subdue the activity of ethylene in many fruits and vegetables (Cliff, Lok, Changwen Lu & Toivonen PMA, 2009). The frequency of ethylene production in harvested tomato is suggestive of the metabolic actions within the produce. If the shell life of the produce is shorter, it is an indication of higher metabolic activities in the harvested produce. Even though, the purpose of every post-harvest technology is to slow or reduce the metabolic activities connected to the ripening process such as colour change, cell wall breakdown, and respiration rates in the harvested produce which in turn will enhance its shelf life (Watkins, 2008). One disadvantage of 1-MCP in the preservation of quality produce is the result of non-uniform ripening (Mostofi, Toivonen, Lessani, Babalar & Lu, 2003). The storage of green fruits using 1-MCP should be done cautiously to attain uniform ripeness. Educating and training tomato handlers on how to use 1-MCP in tomatoes will help reduce some amount of post-harvest loss associated with the produce.

b. Calcium Chloride (CaCl2) Application

The application of post-harvest calcium chloride (CaCl2) is recently gaining prominence as a result of its encouraging effects on shelf life whereas maintaining quality of many fruits and vegetables (Senevirathna & Daundasekera, 2010). It is established that calcium chloride defers ripening and senescence, decreases respiration, elongates shelf life, upholds firmness, and lessens physiological disorders of tomatoes (Lara, Garca & Vendrell, 2004). Research has proven that CaCl2 treatment method lessens fungal attack, slows down fruit ripening, preserves mechanical integrity of cell walls of crops suspends softening and increases storage life by almost 3 months crops stored at 0^0C (Lara, Garca & Vendrell, 2004). In

addition to the benefits of CaCl2, it is very cheap and soluble which can be dissolved into any concentration for use by producers and its affordability makes it easy to prepare the solution.

The FAO (1988) also recommends insecticide and that ideally, its correct or proper way of applying should be two weeks prior to harvesting. This is because improper or incorrect way of applying insecticide is likely to reduce the produce quality and eventually cause food poisoning.

2.7 Challenges Facing Tomato Farmers and Retailers

Challenges facing the tomato value chain include Production constraints, storage constraint, marketing challenges, funding, and research and development (Ugonna, Jolaoso & Onwualu, 2015; Kumar & Sarma, 2018). In addition, Ajagbe *et al.* (2014) ranked insufficient fiscal support as a serious problem facing harvest tomatoes. Financial support is a vital element for expanding agriculture. Yeboah (2011, p.62-63) postulated that lack of credit, high costs of inputs, lack of irrigation water near farms, poor access roads and non-existence of technical assistance are the problems tomato farmers face in tomato production. On the part of retailers, poor access roads to the farms, undependable transport, high transportation cost, non-existence of financial assistance, non-existence of appropriate storage facilities and non-existence of preservation technological know-how for preserving tomatoes are the problems they face.

Other challenges faced by tomato farmers and retailers are persistent tomatoes processing technique, insufficient extension service support, low request for dried tomatoes, insufficient market information on tomatoes, high cost of farm labour, pest

and diseases problems, lack of technical know-how on post-harvest and non-existence of sup-to-date processing facilities (Ajagbe *et al.* 2014).

Yeboah (2011) stated that farmers and traders in developing countries report many problems that affect them. Notable among them were lack of credit facilities, high cost of inputs such as fertilizers and agrochemicals, irrigation difficulties and lack of technical support. On lack of credit facilities from financial institutions, Yeboah (2011) claimed that financial institutions are often unwilling to advance credit facilities to farmers and traders because of the uncertainties of the output and trade dynamics. Regarding high cost of inputs such as fertilizers and agrochemicals, the scholar was of the firm belief that farmers and retailers most often make only marginal profit or cannot not break even. This problem is further acerbated by poor pricing by traders who take advantage of the perishability of the produce and the fact that farmers do not have alternative market avenues. Concerning the irrigation difficulties, the scholar asserts that farmers most often travel long distances to fetch water when there is delay or failure in raining to irrigate their farms. On lack of technical support, the scholar comments that technical officers' main concern is the production than the post-harvest management of the produce. As a result of this, farmers are able to enhance crop yields easier than improve upon the minimization of post-harvest losses. More importantly, each time there is post-harvest innovation, technical officers and recognized farming experts essentially appear to place more attention on the education and training of farmers and not of traders through whom the produce spends most of their unrefined post-harvest shelf life.

2.7.1 Processing Constraint

The processing of tomatoes is faced with challenges including inadequate raw material especially improved varieties, for processing, high cost of processing, and packaging machinery and equipment, preference of farmers and middlemen to sell to urban markets rather than sell to processors, inadequate infrastructure such as water and power supply and harassment of investors by law enforcement agencies on raw material and furnished product. These challenges result in high cost of production for industries involved in tomato processing.

Ajagbe *et al.* (2014) recommended that to reduce the post-harvest losses and over supply/glut to the markets, it is essential that the surplus and over riped produce be separated and processed. With this, Ajagbe *et al.* (2014) revealed that 84.67% of the respondents indicated sun-drying of their tomatoes surplus as the best way of preserving their produce, whereas 15.33% of respondents recommended grinding and boiling for preserving tomatoes. Ajagbe *et al.* (2014), nonetheless, expressed a contrary opinion that the post-harvest processing and preservation techniques which were outlined by tomato handlers in their study are ineffective because large quantities of tomato fruits are harvested, thus high post-harvest wastages. This is reinforced in the findings of Adekunle *et al.* (2014) that modernized tomato processing systems are basically low in developing economies.

2.7.2 Production and Retailing Constraints

Yeboah (2011) observed that the occupational activities of farming and trading demand some degree of understanding and appreciation of some rudimentary principles. In the case of a tomato production, a farmer with low level of education would find it extremely difficult to appreciate and apply the fundamental principles of

production that can have undesirable post-harvest consequences. They may also not be responsive to the principles underpinning perishability of tomatoes that would inform them to step-up their game to minimize or total eradicate losses. With respect to traders (especially retailers), lack of technical know-how regarding the post-harvest handling of tomato as a result of low level of education will witness the manifestation of massive perishability leading to incurring of cost or loss of business capital. It is, therefore, critical for tomato handlers to undergo some form of education or training in tomato post-harvest handling practices to avert avoidable losses.

Production constraints includes use of poor agricultural practices, unwillingness of communities to give out land to interested investors to go into commercial production, lack of good quality seeds, and over application of fertilizer and other insecticide by farmers. Other constraints include high cost of critical production inputs such as irrigation equipment greenhouse machinery, fertilizer and pesticides. Lack of experienced technical man power in tomato production and management, infrastructure and basic amenities such as road and water, lack of good quality seed and non – adoption of good agricultural practices (GAP) results in poor yields and low productivity. Inadequate transport facilities for instance the conditions of the road linking farm areas to the markets are poor and sometime inaccessible and this leads to losses as their produce will not be accessible and high transportation cost reduce the profit. The breakdown of vehicle and basket containing tomatoes lead to losses and high marketing cost for whole seller, retailer and consumers.

2.7.3 Storage Constraints

The traditional methods of storing tomato are normally meant to improve the shelf life of the produce, even though are associated with some degree of losses. For instance,

drying of tomatoes occasions a loss in quantity of the crop, since water that constitute a large proportion of the crop's mass is removed. Canning does not essentially lose as much humidity content as drying but then as a result of the crop acidification, there occurs a loss in flavour and sweetness. Freezing conditions the crop whole but leads to freezing injury. This happens due to a situation where damages take place along the crop membranes leading to loss of some flavours and a soft meaty texture when they are returned to room temperature.

Kitinoja *et al*. (2009) reported that there is lack of storage facilities on the farm, at the wholesale or retail markets coupled with lack of ventilation and cooling of tomatoes in developing countries. Other forms of storage include loading of produce in cold stores, stacking of produce too high (above container strength) and the practice of combining produce with other crops that have different temperature and relative humidity rations. In respect of the various methods of storing the produce, some key factors must be taken into consideration in order to identify the best storage method. In doing this, Kitinoja *et al.* (2009) proposed the initial determination of varieties of the produce to those that can be stored in a certain appropriate way to achieve the best results.

The FAO (2008) recommend the storage of green tomatoes at the 10^0C with the optimum humidity of about 80% for 16 – 24 weeks. Ashby (2000) also recommends 13^0 to 21^0C and a comparative humidity of 90 to 95% as the best storage and transportation conditions for matured green tomatoes.

There are no storage facilities in the Upper West Region and this contributes greatly to the post-harvest losses in the Region any time there is a bumper harvest. Some of these storage facilities include cold room storage facilities, processing facilities and cold transport means. All these are lacked in the Region and hence lead to losses.

2.8 Concept of Value Chain in Tomato Production

Porter (1985) defines "value chain" as a depiction of an organization's value-adding arrangements, in respect of its pricing approach and cost structure and identifying the inter-dependencies and influences between vertically-displayed players in the creation of value for an organization through primary activities (which directly help in adding value to the production of goods and services) and auxiliary activities (which have an indirect result on the final value of the product (Sarma & Ali, 2018). Gereffi, Humphrey & Sturgeon (2005), later expanded this definition by incorporating governance relationships between players in the value chain by generally placing emphasis on the linkages and relationships both between and within actors in every stage of production as was also observed by Gibbon (2008), Kaplinsky (2000), Kaplinsky & Morris, (2001).

The value chain study in the agriculture sector operates with six sets of tools and steps (Kaplinsky & Morris, 2001) such as the following:

(i) the investigation begins with place in order a commodity for value chain development;

(ii) diagramming of the value chain;

(iii) exploration of the value chain performance with respect to costs, prices and margins;

(iv) examination of technology, knowledge and improvement potentials through assessment of gaps in technology and knowledge and existing or future opportunities;

(v) value chain governance which is used to find interested party influencing governance, rules and regulations and their enforcement; and

(vi) connections among the interested party, referring to their relationships.

The value chain concept also involves a chain of actions that are associated with adding value to a produce through the production and distribution processes of each activity (Schmitz, 2005). A firm's competitive edge over others is based on its product's value chain. The goal of the firm is to provide maximum value to the ultimate consumer for the minimum likely total cost to the firm, thereby maximizing profit (Porter, 1985). The concept of value chain in tomato production involves the comprehensive range of activities needed to transport a produce from its harvesting stage through the post-harvest stage to the final consumer. Kohls & Uhl (1985) are also of the view that a value chain in tomato production comprises a series of actors from input suppliers, producers, and processors, to exporters and buyers engaged in the activities required to bring the tomato crop from its outset to its end use.

In tomato production value chain, MOFA (2008) reported that warm day and cool night temperatures are the requirements for ideal harvest in the crop's production, since excessive temperature and low humidity result in undue flower drops and consequently decrease yields considerably. Nevertheless, it is assumed that tomatoes are highly reactive to cold night temperatures (below 13°C) and that the appropriate temperature range is between 16° and 32°C, because temperatures that are out of range result in sluggish growth, pollination and maturation of the crop (Orzolek *et al.* 2006). Even though tomatoes need a continuous supply of humidity during the growing season, surplus water at any point of growth, particularly after fruit set, may heighten the fruit's vulnerability to cracking (both radial and concentric) that may probably minimize fruit quality and yield (Orzolek *et al.* 2006).

A study by Kitinoja *et al*. (2009) as cited in Yeboah (2011) revealed that essentially all post-harvest value physiognomies of horticultural crops are hereditarily mechanized and will naturally vary in product variety, and as it observed by Robinson

et al. (2010), plant variety choice has considerable influence on yields, even though other factors also account for such yields. Clottey, Karbo & Gyasi (2009) is also of the view that farmers do not generally invest in using unadulterated seed but then re-use seed from the previous crop, which often lead to lower yields and upsurge in disease persistence. They ascribed the assertion to the fact that there was no motivation in investing in viable seed simply because the value in fruit business is the same regardless of the variety and seed quality.

2.9 Conceptual Framework of the Study

The conceptual framework of this study was adapted and modified from Anaba's (2018) conceptual framework on *Factors Driving Postharvest Losses of Tomatoes*, which essentially gives extensive elucidation on factors that drive losses and their attendant challenges along the tomato value chain. The modified frame is named by the researcher as *Tomato Post-harvest Loss Value Chain Model*. The model encapsulates that there are two actors along the value chain. The actors include the tomato grower (farmer) and the tomato marketers (wholesaler and retailer). The tomato can choose to deal only with retailer or use the wholesaler as the intermediary between the grower and the retailer as shown in figure 2.1

Conceptual Framework of the Study

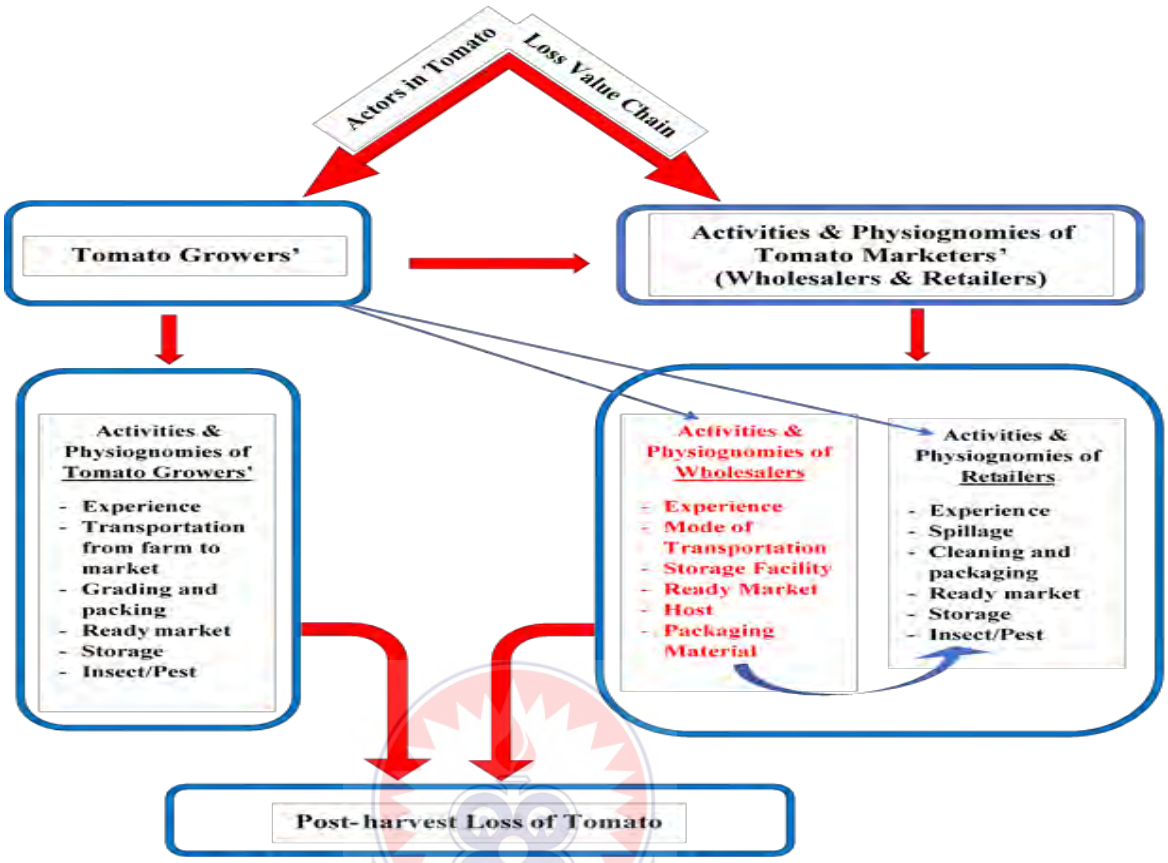


Figure 2.1: Tomato Post-Harvest Loss Value Chain Model

Source: Adapted and Modified from Anaba (2018)

According to Anaba (2018), the prevailing factors that trigger post-harvest losses at the farmer level comprise *experience, transportation method, storage facility, ready market, location of the farm, and insect/pest*. It is also established that *packaging material, heat, ready market, transportation method and experience* are some of the factors that engender post-harvest loss at the wholesale level, and at the retail level, *location of the market centres and infrastructure available, ready market, storage* are some of the factors that initiate loss within the value chain (ibid). Nevertheless, unavailability of ready market and lack of proper storage facilities are the factors commonly found among the actors along the value chain. Principal factors that

occasion post-harvest losses among actors along the chain comprise pest and diseases, rot, bruises, and destruction by rodents (ibid). The scholar reinforces the point that the poor state of roads also accounts for congestion of tomatoes that leads to mechanical injuries of the produce. Anaba (2018) is of the view that excessive hot temperature in the tropics accounts for higher magnitude of post-harvest losses because heat causes fresh tomatoes to rot. The packing houses used by actors along the value chain at the farm and sale points contribute substantially to post-harvest losses. According to the scholar, fresh tomatoes must be kept within the appropriate *moisture, temperature, and humidity* conditions because weather variations have huge impact post-harvest losses. The place and period for storing freshly-harvested tomatoes essentially influence the impact on post-harvest losses. In sum, all the activities and characteristics of the tomato handlers within the Tomato Post-Harvest Loss Value Chain Model transition into post-harvest losses of the produce due to the conditions that occasion those activities and characteristics of the handlers.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The research design used in this study was the Triangulation Design model with the main aim of obtaining different but complementary data on the same topic (Morse, 1991, p. 122). As observed by Creswell and Plano Clark (2007) and Office of Behavioural and Social Sciences Research (2001), this type of research design is described as a philosophically underpinned method of inquiry, where the qualitative method was used to triangulate the quantitative research design in this study. Hence, the study employed the Descriptive survey method.

3.2 Study Population

The population of this study was the tomato farmers and retailers in the Upper West Region of Ghana. In this study, the target population involved tomato farmers and retailers from four selected districts in the Upper West Region namely Wa Municipal, Wa East District, Wa West and Jirapa District. The total number of the target population was 220 from the four selected districts. The accessible population was 138 farmers and retailers from six (6) tomato growing communities in the selected Districts within the Upper West region of Ghana.

3.3 Sample Size

The study employed the use of randomized purposive sample technique to obtain data.

As a result of this, the researcher selected 138 tomato farmers (57) and retailers (81) as the accessible population and sampled 71% (98) of them as the sample size for the

study. To enhance credibility to the study, a sample size of 41 tomato farmers and 57 of tomato retailers were used for this study. It is important to observe that four (4) Agriculture Extension Officers were interviewed to validate the findings obtained from the tomato farmers and retailers of this study.

3.4 Sampling Technique

The sampling techniques employed for the study were convenience, purposive and random sampling.

3.4.1 Convenience Sampling

Convenience sampling was used to select the Region and further used to select the Districts and Municipal Assembles for the study. This sampling technique was chosen because the researcher works and lives in the Region where the study was conducted.

3.4.2 Purposive Sampling

Purposive sampling method was also used to select the communities from the various Districts and Municipal Assembles within the Upper West Region for the study. This sampling method was also used to select four (4) Agriculture Extension Officers from the four districts within the study region. The reason for their selection using this sampling technique was that they exhibited most of the characteristics needed for the study. They are more knowledgeable in this field and possessed very vital information needed for the study. According to Agyedu, Donkor and Obeng (1991), this sampling method permits researchers to intentionally sample only participants whose knowledge on the subject is essential in understanding the subject under investigation.

3.4.3 Randomized Purposive Sampling

In this study after the participants have been purposefully sampled, random sampling technique was further employed to accidentally select a fraction or a reasonable proportion of the participants (sample size - 98), which represented 71% of the accessible population (138) for the study.

3.5 Data Collection Instrumentation

Hsu and Sandford (2010) describe instruments for data collection as the tools used by researchers to measure variables of importance in the data gathering process. There are several research tools for data gathering, nevertheless, considering the data required and the nature of the study, interview and questionnaire instruments in relation to descriptive survey method were merged and found to be most appropriate for obtaining the right data in this study. The questionnaires were administered to the farmers and retailers and were ably assisted by the researcher to gain full understanding of the questions asked. The activities of the farmers and retailers were closely observed by the researcher for a period of two months.

3.5.1 *Questionnaire*

Malhotra and Birks (2007) describes questionnaire as a set of questions for collecting data from large group(s) of individuals at the same time and respondents are free to express their views without being intimidated by the researcher. Two set of questionnaires were designed to obtain data from tomato farmers and retailers as shown in appendix A (questionnaire for tomato farmers) and B (questionnaire for retailers).

In this study, standardized structured questionnaire was used to gather data from respondents for the study. Close ended questions were used to seek the views of respondents on the handling practices of tomatoes by tomato producers and retailers, cause of post–harvest loss of tomato, the challenges tomato farmers and retailers encounter during production, storage and sales period and the common treatment methods used in the study area.

3.5.2 *Interview*

Interview can be defined as structured or unstructured oral communication between the interviewer and the interviewee, through which information is obtained for a study in the course of the process (Burns & Grove, 2011). With the aid of an interview guide (Appendix C), a formal interview was conducted by organising the interview guide in a form of questionnaire and sent to the selected respondents to read through first before the researcher went and ask for their views. The researcher personally conducted the interview in this research project. Interview was conducted to obtain data from four Agriculture Extension Officers in four selected districts within the Upper West Region about the post-harvest handling practices, causes of post-harvest loss of tomatoes, challenges facing tomato farmers and retailers and the common tomato treatment methods used in the area.

3.6 Validation and Reliability of Instruments

Validation of instrument gives an elucidation on how effective the systems of measurement in a study are captured by the data obtained through the research questions. Validation confirms the precision and validity of the study design. Validation also determines the degree at which the results of the study can replicate

similar results in a different place, and can be generalized to other populations or circumstances. Validation ensures that the study conducted and reported is an illustration of the validity and reliability of the research. This should align with the theoretical and conceptual framework in Chapter two**.**

The instruments used in this study proved to be valid as a result of the conceptual framework. This framework has been proven by Anaba (2018) to be very reliable to obtained data of such kind in his study. More importantly, face and content validity of the instruments were carried out by the researcher's supervisor and others in the Catering and Hospitality Department of the University.

To ensure reliability of the instruments used in this study, pilot-testing was conducted in four other districts in the region namely: Lawra, Nadowli/Kaleo, Issah, Busie, Daffiama and Lambussie/Karni districts. These districts were chosen because they were the second leading producers of tomatoes in the Upper West Region. Drafted copies of the questionnaire and interview guide were administered to farmers, retailers and Agric Extension Officers. The retailers and farmers were randomly selected and briefed. Respondents were met at an appropriate place to discuss any ambiguity and doubt that they might face with any aspect of the draft questionnaire.

3. 7 Ethical Consideration

Ethical consideration is simply the standards of behaviour that separates conventional and unconventional behaviour. They simply refer to performing actions that are ethically and right when carrying out a study. The subsequent ethical issues were considered.

The researchers sought consent to conduct the study from the University using an introductory letter. Participants of the study were briefed on the nature and purpose of

the study before eliciting information from them. Respondents were also assured of high standard of confidentiality. Additionally, the participants of the study were informed that the data obtained from them is exclusively for academic purposes.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Demography of the Tomato Handlers (Farmers and Retailers)

The demographic information of the study participants in this study presents details of the population structure, which aids to fashion out fair representation of the various participants that represented the entire population. The study analysed demographic characteristics of the respondents by establishing their gender, age, marital status and nationality.

The study therefore sought to determine how the sampled participants (tomato farmers and retailers) were spread by gender, age, nationality, marital status, and to allow for tabulation of response. Data in table 4.1.1 shows how the participants (tomato farmers and retailers) of the study were distributed by gender, age, nationality and marital status.

Table 4.1: Demography of Respondents

Variables	Frequency (*f*)	Percentage (%)
Farmer Respondents		
Gender		
Male	22	53.7%
Female	19	46.3%
Total	**41**	**100.0**
Age		
Below 18	0	0
18 – 24 years	12	29.3%
25 – 40 years	15	36.6%
41 – 55 years	7	17.1%
Above 55 years	6	15.6%
Total	**41**	**100.0**

Nationality		
Ghanaian	40	98%
Non-Ghanaian	1	2%
Total		
Marital Status		
Married	16	58.5.7%
Single	4	9.8%
Divorced	4	9.8%
Widowed	3	7.3%
Separated	6	14.6%
Total	**41**	**100.0**
Retailer respondents		
Gender		
Male	16	39%
Female	25	61%
Total	**41**	**100.0**
Age		
Below 18	0	0
18 – 24 years	9	15.8%
25 – 40 years	22	38.6%
41 – 55 years	20	35.1%
Above 55 years	6	10.5%
Total	**41**	**100.0**
Nationality		
Ghanaian	52	91.2%
Non-Ghanaian	5	8.8%
Total	**57**	**100**
Marital Status		
Married	40	70.1%
Single	3	5.3%
Divorced	5	8.8%
Widowed	6	10.5%
Separated	3	5.3%

Total	**57**	**100.0**

The data obtained in this study revealed that the gender of the sampled farmer respondents were 53.7% (majority) for males and 46.3% females. This was an indication that more males were engaged in tomato farming compared to a few females in tomato production in the study area. It can also be inferred from the outcome of the study that gender was not fairly distributed in the sampled tomato farmers' population, a situation clearly described by Yeboah (2012) as a male-dominating profession. Anaba (2018) makes similar observation that a greater number of farmers in the Upper East Region were males, a strong indication that tomato farming is dominated by males, which could be attributed to the fact that women mostly performed almost domestic chores and may not necessarily have equal amount of time for tomato farming like their male counterparts. This fallout also supports similar findings by current research by Awunyo-Victor, Wongnaa and Aidoo (2016) that farming in Ghana is a male-dominated profession.

The data obtained in this study also revealed that the gender of the sampled retailer respondents were 61.4% (majority) for females and 38.6% males. It can therefore be inferred that tomato retailers in the study area were predominantly women.

Data in Table 4.1 also indicate that 29.3% of tomato farmers in the study area were aged between eighteen (18) to twenty-four (24) years, while those between twenty-five (25) and forty (40) years were 36.6%, those between forty-one (41) and fifty-five (55) years were 17.1%, and those above fifty-five (55) were 14.6%. No farmer was below eighteen (18) years.

In Table 4.1, the data obtained from the respondents indicated that 15.8% of tomato retailers in the study area were aged between eighteen (18) to twenty-four (24) years, while those between twenty-five (25) and forty (40) years were 38.6%, those between

forty-one (41) and fifty-five (55) years were 35.1%, and those above fifty-five (55) were 10.5%. No retailer was below eighteen (18) years.

Table 4.1 shows that majority (97.6%) of the tomato farmers were Ghanaians, while only 2.4% (1) was a non-Ghanaian.

Data in table 4.1 also shows that majority (91.2%) of the tomato retailers were Ghanaians, while only 8.8% (5) were non-Ghanaians.

Data shown in Table 4.1 revealed that majority (58.5%) of the sampled farmer respondents were married, while 9.8%, 9.8%, 7.3% and 14.6% were single, divorced, widowed and separated respectively.

Data presented in table 4.1 indicated that majority (70.1%) of the sampled retailer respondents were married, while 5.3%, 8.8%, 10.5% and 5.3% were single, divorced, widowed and separated respectively.

4.2 Post-Harvest Handling Practices of Tomatoes among Farmers and Retailers in Some Selected Districts in the Upper West Region

Data was collected on the post-harvest handling practices of tomatoes by tomato farmers and retailers and the results are presented in table 4.2.

Table 4.2: Post-Harvest Handling Practices of Tomatoes among Farmers

No.	Questionnaire Items	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	Tomatoes are usually matured (ripped) and harvested in their red states	1 (2.4%)	0 (0%)	0 (0%)	23 (56.1%)	17 (41.5%)
2	Tomatoes are more often harvested in the morning	0 (0%)	1 (2.4%)	1 (2.4%)	32 (78%)	7 (17.1%)
3	Tomatoes are often harvested and heaped on the ground before selling to	2 (4.9%)	14 (34.1%)	10 (24.4%)	13 (31.7%)	2 (2.4%)
4	Farmers do clean and disinfect their tomato produce after harvesting	2 (29.3%)	14 (34.1%)	13 (31.7%)	12 (4.9%)	0 (0%)
5	Tomato produce are often sorted and graded after harvesting	1 (2.4%)	16 (39%)	4 (9.8%)	17 (41.5%)	3 (7.3%)
6	Tomato farmers do precool their tomato produce before transporting	3 (7.3%)	21 (51.2%)	12 (29.3%)	5 (12.2%)	0 (0%)
7	There are poor transportation networks leading to tomato farms	0 (0%)	4 (9.8%)	2 (4.9%)	31 (75.6%)	2 (4.9%)

8	Farmers in my community often get training in post-harvest management	19 (46.3%)	11 (26.8%)	3 (7.3%)	6 (14.6%)	2 (4.9%)
9	Farmers do not have refrigerated vans to transport their produce	3 (7.3%)	4 (9.8%)	3 (7.3%)	28 (68.3%)	3 (7.3%)
10	Farmers do place their tomato produce in wooden crates for sales	3 (7.3%)	4 (9.8%)	3 (7.3%)	31 (75.6%)	0 (0%)
11	Tomatoes are usually placed in woven baskets for sale to middlemen	1 (2.4%)	4 (9.8%)	2 (4.9%)	33 (80.5%)	1 (2.4%)
12	Tomatoes are often placed in buckets for sale to traders	0 (0%)	4 (9.8%)	6 (14.6%)	39 (73.2%)	1 (2.4%)
13	Farmers often transport their tomatoes using motor bicycles/tri-cycles	0 (0%)	4 (9.8%)	2 (4.9%)	33 (80.5%)	2 (4.9%)
14	Most farmers used trucks/pick-up to convey their produce to market centres	1 (2.4%)	7 (17.1%0	4 (9.8%)	27 (65.9%)	2 (4.9%)
15	Tomatoes farmers transport their produce by heads to the market centres	0 (0%)	18 (43.9%)	9 (22%)	12 (29.3%)	2 (4.9%)

15	Your tomato farm is far away from the market centres	0 (0%)	2 (4.9%)	1 (2.4%)	29 (70.7%)	9 (22%)
16	Tomatoes usually take long duration before they are bought by buyers/ traders	0 (0%)	2 (4.9%)	4 (9.8%)	30 (73.2%)	7 (17.1%)
17	The hand-picking method mainly used by farmers delays the harvesting process	0 (0%)	2 (4.9%)	4 (9.8%)	30 (73.2)	5 (12.2%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

Tomato farmers responded in table 4.2 that majority (56.1%) of them agree with the statement that their tomatoes are usually matured (ripped) and that they are usually harvested in their red state, with (41.5%) of them strongly agreeing to this statement. Very few (2.4%) of them strongly disagreed with this assertion.

Majority (78%) of the respondents answered in agreement that their tomatoes are more often harvested in the morning, with (17.1%) of them strongly in agreement, while 2.4% of the disagreed and (2.4%) of them remained undecided.

About (34.1%) of the farmers disagreed that their tomatoes are often harvested and heaped on the ground before sorting and grading, while (31.7%), (2.4%) and (4.9%) of them agreed, strongly agreed and strongly disagreed respectively. Exactly (24.4%) of the respondents remained undecided as to whether or not they often harvested and heaped their produce on the ground before sorting and grading.

It was disagreed by (34.1%) of farmers that they do clean and disinfect their tomatoes after harvesting, while (29.3%) strongly disagreed and (31.7%) of them remained undecided whereas (4.9%) of the farmers agreed to this assertion.

Exactly (41.5%) of the farmer respondents strongly disagreed that they sort and grade their produce after harvesting, whereas (39%) disagreed, (2. 4%) strongly disagreed, (7.3%) agreed and (9.8%) remained undecided.

When asked as to whether farmers precool their produce before transporting, majority of the respondents (51%) disagreed to the statement, (7.3%) strongly disagreed, (12.2%) agreed and (29.3%) of them remained undecided to the statement.

When enquired whether there were poor transportation networks leading to tomato farms, (75.6%) representing majority agreed that there were indeed poor transportation networks leading to their tomato farms, whereas (4.9%) also strongly agreed, (9.8%) disagreed and (4.9%) of them remained undecided.

Regarding the provision of training in post-harvest management of tomatoes, (46.3%) of the farmer respondents strongly disagreed with the statement that farmers in their respective communities often receive training in post-harvest management of tomatoes with (26.8%) in disagreement, while (14.6%) agreed, (4.9%) strongly agreed and (7.3%) remained undecided.

Majority (68.3%) of farmers agreed with the statement that they do not have refrigerated vans to transport their produce to marketing centres, whereas (7.3%) strongly disagreed to the statement, (9.8%) disagreed and (7.3%) remained undecided.

Also, majority (75.6%) of the participants agreed that farmers do place their tomato produce in wooden crates for sales as against (7.3%) strongly in disagreement, (9.8%) in agreement and (7.3%) remaining undecided.

Majority (80.5%) of the respondents agreed that tomatoes are usually placed in woven baskets for sale to middlemen, while (2.4%), (9.8%), and (4.9%) strongly disagreed, disagreed and remained undecided respectively.

When asked whether tomatoes are often placed in buckets for sale to traders, (73.2%) of farmer respondents indicated they were in agreement with the assertion that their produce are often placed in buckets for sale to traders, while (9.8%) disagreed and (14.6%) remained undecided.

On whether farmers often transport their tomatoes using motor bicycles/tri-cycles, most (80.5%) of the respondents reported that they agree with the statement, whereas (9.8%) disagreed and (4.9%) remained undecided.

On whether most farmers used trucks/pick-up to convey their produce to market centres, most (65.9%) of the respondents agreed to the statement, while (2.4%) strongly disagreed, (17.1%) disagreed and (9.8%) remained undecided.

On the issue of tomato farmers transporting their produce by heads to the market centres, (43.9%) disagreed, contrary to (29.3%) agreeing, (4.9%) strongly disagreeing with (22%) remaining undecided.

Regarding the distance between the farm and market centres, majority (70.7%) of the farmer respondents agreed with the statement that their tomato farm is far away from the market centres, whereas (22%) strongly agreed, (4.9%) disagreed and (2.4%) remained undecided.

With respect to tomatoes usually taking long duration before they are bought by buyers/ traders, majority (73.2%) of the respondents agreed to the statement, (17.1%) strongly agreed, while (4.9%) disagreed and (9.8%) remained undecided.

Most (73.2%) of the sampled respondents agreed and (12.2%) strongly agreed with the statement that the hand-picking method mainly used by farmers delays the harvesting process contrary to (4.9%) disagreeing and (9.8%) remaining undecided.

The findings of this study indicated that almost all tomato farmers (97%) wait for their tomato produce to be matured red before harvesting them. This findings is in contradiction with the situation generally described by Yeboah (2011) and Orzolek *et al.* (2006) contending that tomatoes for the retail market are best harvested at the mature green stage to avert the fruit from becoming overly ripped during long transportation and handling. The scholars recommend that tomatoes should be left on the stalk to ripe if they can be conveyed to market quickly and in good condition. In fact, this handling practice was not being adhered to in the study area since majority of the respondents harvested their tomatoes in a matured ripped reddish stage. It however takes a longer duration for it to be conveyed to the marketing centres and this could render the produce perished before reaching its final destination. Ashby

(2000) further recommends that the appropriate condition to harvest and transport tomatoes is when they in the freshly green matured state.

The study identified morning harvest of tomatoes as one of the best handling practices of tomato because most (98%) of the respondents affirmed that this was the usual practice by tomato handlers (farmers) in the study area. This finding support similar findings of Yeboah (2011) and earlier findings by Gould (1992) that the success of any good post-harvest handling method depends largely on the initial ambient conditions the freshly harvested tomato is subjected to and therefore, recommended harvesting under cold condition preferably early morning or late evenings as a method to cool harvested tomato fruit.

The study also established that about 80% of tomato farmers do not sort and grade their tomatoes after harvesting. This revelation is contrarily to the ideal practice which prevails that harvested tomatoes should be sorted and graded in order to get rid of damaged produce so as to prevent the possibility of contamination (Kintinoja *et al.,* 2005). They also do not precool their produce before transportation to the market. This is in affirmation to similar finding by Yeboah (2011) that connotes that tomato farmers do not exercise pre-cooling of harvested tomatoes before packing them into bins, they generally do not know of the principle of pre-cooling. This might be as a result of the fact most of them harvested their produce early in the morning where there is no field heat or lack of skills and logistics o practice pre-cooling.

It became evident in the study that transportation is one of the handling practices of tomatoes. In this study, post-harvest loss of tomatoes was attributed to poor transportation system. This was because the produce sustains bruises and mechanical damage as a result of the bad nature of roads they travel on and the transport systems that are being used. This finding reaffirms similar studies by Anaba (2018) and

Barbosa-Canovas (2003) that bad transportation system worsens the produce vulnerability to deterioration and microbial development.

In this study, it was established that close to 69% of tomato farmers do not have refrigerated vans to transport their produce. A situation largely attributed to lack of support from non-governmental organizations and other stake-holders.

Packaging of farm produce has high chance of minimizing waste. Packing tomatoes in woven baskets, wooden boxes, buckets, tricycles, trucks were identified as common handling practices that have been adopted by tomato handlers in this study. A study by Issahku (2012) buttressed this assertion. In most cases, some of these handling practices become driving factors of post-harvest losses as observed by Anaba (2018) and Issahku (2012). To them, freshly harvested tomatoes that are packed in wooden boxes and other such containers experience high losses.

Table 4.3: Post-Harvest Handling Practices of Tomatoes among Retailers

No.	Questionnaire Items	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	Tomatoes are usually sold in a matured reddish (ripped) form to retailers	1 (1.8%)	0 (0%)	2 (3.5%)	49 (86%)	5 (8.8%)
2	Tomatoes are more often harvested in the morning before they are bought by retailers	0 (0%)	4 (7%)	7 (12.3%)	42 (73.7%)	4 (7%)
3	Tomatoes are often harvested and heaped on the ground before selling to retailers	0 (0%)	10 (17.5%)	14 (24.6%)	31 (54.4%)	2 (3.5%)
4	Retailers often sort and grade tomatoes after buying from farmers	0 (0%)	3 (5.3%)	12 (21.1%)	38 (66.7%)	4 (7%)
5	There are poor transportation networks leading to tomato farms	0 (0%)	0 (0%)	7 (12.3%)	47 (82.5%)	3 (5.3%)
6	Retailers do not have refrigerated vans to transport their produce	0 (0%)	2 (3.5%)	3 (5.3%)	49 (86%)	3 (5.3%)
7	Retailers do place their tomato produce in wooden crates for sales	0 (0%)	5 (8.8%)	5 (8.8%)	43 (75.4%)	4 (7%)
8	Tomatoes are usually placed in woven baskets before they are being sold to customers	1 (1.8%)	10 (17.5%)	1 (1.8%)	40 (70.2%)	5 (8.8%)
9	Tomatoes are often placed in buckets before they are being sold to customers	0 (0%)	7 (12.3%)	3 (5.3%)	41 (71.9%)	6 (10.5%)
10	Traders often transport their tomatoes to the market centres using motor bicycles/tri-cycles	1 (1.8%)	1 (1.8%)	4 (7%)	46 (80.7%)	5 (8.8%)

11	Most retailers used trucks/pick-up to convey their produce to market centres	0 (0%)	1 (1.8%)	6 (10.5%)	44 (77.2%)	6 (10.5%)
12	Tomatoes retailers transport their produce by heads to the market centres for sale to customers	0 (0%)	7 (12.3%)	10 (17.5%)	37 (64.9%)	3 (5.3%)
13	Tomato farm is far away from the market centres	0 (0%)	1 (1.8%0	9 (15.8%)	41 (71.9%)	6 (10.5%)
14	Tomatoes usually take long duration before they are bought by customers in the market centres	0 (0%)	3 (5.3%)	9 (15.8%)	41 (71.9%)	4 (7%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagre

4.3 Post-Harvest Handling Practices of Tomatoes among Retailers in Some Selected Districts in the Upper West Region of Ghana

Tomato retailers in table 4.2.2 revealed that tomatoes are usually sold to them in their matured (ripped) reddish state by farmers. Majority (86.1%) of the respondents agreed to this assertion, with (8.8%) of them strongly agreeing to this statement. Very few (1.8%) of them strongly disagreed with this assertion whereas (3.5%) of them remained undecided.

Majority (73.7%) of the respondents answered in agreement that tomatoes are more often harvested in the morning by farmers before being sold to retailers with (7%) of them strongly in agreement, while (7%) of the respondents disagreed and (12.3%) of them remained undecided.

About (54.4%) of the retailers agreed that tomatoes are often harvested and heaped on the ground before being sold to them, while (17.5%) of them disagreed. Exactly (24.6%) of the respondents remained undecided as to whether or not farmers harvested and heaped their produce on the ground before selling to retailers.

Exactly 66.7% of the retailer respondents agreed to the statement that they sort and grade tomatoes after buying from farmers before selling, whereas (7%) strongly agreed, (5.3%) disagreed and (21.1 %) remained undecided**.**

When enquired whether there were poor transportation networks leading to tomato farms, (82.5%) making a majority of the retailers agreed that there were indeed poor transportation networks leading to tomato farms, whereas (5.3%) also strongly agreed and (12.3%) of them were undecided.

Majority (86%) of retailer respondents agreed with the statement that they do not have refrigerated vans to transport tomatoes, whereas (53%), (3.5%) and (5.3%) strongly agreed, disagreed and remained undecided respectively.

Also, majority (75.4%) of the participants agreed that retailers do place their tomato produce in wooden crates for sales as against (8.8%) who disagreed, with (8.8%) remaining undecided.

Majority (70.2%) of the respondents agreed that tomatoes are usually placed in woven baskets for sale to customers, while (8.8%), (1.8%), (17.5%) and (4.9%) strongly agreed, strongly disagreed, disagreed and remained undecided respectively.

When asked whether tomatoes are often placed in buckets for sale to customers, (71.9%) of retailer respondents indicated they were in agreement with the assertion that their produce are often placed in buckets for sale, (10.5%) strongly agreed, while (12.3%) disagreed and (5.3%) remained undecided.

On whether farmers often transport their tomatoes using motor bicycles/tri-cycles, most (80.7%) of the respondents reported that they agree with the statement and 8.8% strongly agreed, whereas 1.8% disagreed, 1.8% strongly disagreed and 7% remained neutral.

On whether most retailers used trucks/pick-up to convey their produce to market centres, most (77.2%) of the respondents agreed and (10.5%) strongly agreed, while (1.8%) disagreed and (10.5%) remained undecided.

On the issue of tomato retailers transporting their produce by heads to the market centres, 64.9% (majority) agreed and (5.3%) strongly agreed in contrast to (12.3%) disagreeing with (17.5%) remaining neutral.

Regarding the distance between the farm and market centres, majority (71.9%) of the retailer respondents agreed with the statement that tomato farms are far away from the

market centres, whereas (10.5%) strongly agreed, (1.8%) disagreed and (15.8%) remained undecided.

With respect to tomatoes usually taking long duration before they are bought by customers, majority (71.9%) of the respondents agreed, (7%) strongly agreed, while just (5.3%) disagreed and (15.8%) remained neutral.

Findings from the study revealed that most retailers buy their tomatoes from farmers when they are reddish red (fully ripped). This means they are harvested ripped and ready for immediate sale and should not be subjected to long distance of travel. Freshly harvested fruits continue to respire after harvest and can easily deteriorate if not sold or consumed after a short period. This findings is contrarily to the assertion of Yeboah (2011) which reiterated that tomatoes for the retail market should be harvested when matured green to give room for longer distances and hours of travel to the marketing centres before it becomes overly ripped and finally deterioration.

Again, majority of the retailers agreed that they sort and grade their tomatoes in order to separate wholesome and damaged ones before selling. This practiced is highly commendable as partially ripped, overly ripped, damaged and wholesome tomatoes are separated/detached to ensure longer keeping value of quality ones and also to avoid transfer of microorganisms .This practice is highly recommended by Arjenaki *et al*. (2013) which affirmed that sorting limits the spread of microorganisms from unhealthy to healthy fruits.

It is established from the study that one of the handling practices that easily subject the produce to perishability is transportation. This is as a result of the fact that poor road network coupled with inappropriate transport systems used to convey tomatoes to marketing centres subject the produce to mechanical damages causing punctures and bruises on the fruit. This findings is in affirmation with similar findings from

Barbosa-Canovas (2003) which revealed that bad transport systems worsened the produce vulnerability and further aggravate microbial contamination.

The study also identified inappropriate packaging as one of the handling practices of tomatoes by retailers which increases damage caused on tomatoes. Close to 85% of the tomato retailers affirmed that packaging tomatoes in basins, buckets and similar containers which do not allow free air circulating on the produce and exposure to severe sunshine generates excessive heat around the produce and eventually influence spoilage. This revelation is in agreement with similar argument raised by Idah et al. (2007) which indicated that undignified post-harvest sanitation, improper packaging systems, mechanical damaged, poor transport, undulating and irregular nature of the roads are some of the rough handling practices that leads to potential losses.

Esguerra et al. (2018) in support of the findings explained that the characteristics of tomatoes does not support improper handling which can easily leave punches, holes, wounds and pathways to loss of water and other vital nutrients.

4.4 Causes and Challenges of Post-Harvest Losses of Tomato Faced by Tomato Farmers and Retailers

A set of questionnaires were used to elicit responses and identify the common causes and challenges of post-harvest loss of tomatoes among tomato farmers and retailers in the study area.

4.4.1 Causes of Post-Harvest Losses of Tomato Faced by Tomato Farmers

The causes identified by tomato farmers ranges from financial constraints, education (illiteracy), poor road network, inappropriate transport systems among others as seen in table 4.3.

Table 4 4: Causes of Post-Harvest Loss of Tomatoes Faced by Tomato Farmers in the Food Value Chain in Some Selected Districts in the Upper West Region of Ghana

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	I faced massive losses in my tomato production	2 (4.9%)	4 (9.8%)	1 (2.4%)	31 (75.6%)	3 (7.3%)
2	These losses occur through infestation of pests and diseases	1 (2.4%)	8 (19.5%)	1 (2.4%)	30 (73.2%)	1 (2.4%)
3	There is lack of financial support to tomatoes farmers	0 (0%)	4 (9.7%)	0 (0%)	28 (68.3%)	9 (22%)
4	Tomato farmers do not receive technical support services	0 (0%)	3 (7.3%)	2 (2.4%)	31 (75.6%)	5 (12.2%)
5	Tomato farmers receive low prices for their harvest	1 (2.4%)	4 (9.8%)	1 (2.4%)	29 (70.7%)	6 (14.6%)
6	There is limited available ready market for tomato farm produce.	0 (0%)	3 (7.3%)	1 (2.4%)	34 (82.9%)	3 (7.3%)
7	Tomato farmers have inadequate storage facilities	0 (0%)	0 (0%)	2 (4.9%)	30 (73.2%)	9 (2.2%)
8	Tomato farmers have inadequate storage technology	0 (0%)	0 (0%)	2 (4.9%)	33 (80.5%)	7 (17.1%)
9	Tomato farmers do not have modern farming practices	2 (4.9%)	3 (7.3%)	1 (2.4%)	30 (73.2%)	5 (12.2%)
10	There are inadequate processing plants/ factories for tomato produce	0 (0%)	1 (2.4%)	1 (2.4%)	27 (65.9%)	12 (29.3%)

11	Harvested tomatoes have singular use	0 (0%)	16 (39%)	5 (12.2%)	17 (41.5%)	3 (7.3%)
12	Tomato farmers used genetically modified seeds	1 (2.4%)	19 (46.3%)	9 (22%)	10 (24.4%)	2 (4.9%)
13	Farmers of tomatoes do fumigate their tomato plants/farms	2 (4.9%)	18 (43.9%)	10 (24.4%)	10 (25.4%)	1 (2.4%)
14	The variety of tomato seeds used by farmers leads to post-harvest losses	2 (4.9%)	7 (17.1%)	2.4 (4.9%)	27 (65.9%)	3 (7.3%)
15	Tomato produce have peak and off-peak season	0 (0%)	3 (7.3%)	0 (0%)	31 (75.6%)	7 (17.1%)
16	Tomato farmers used inappropriate tools in harvesting	1 (2.4%)	3 (7.3%)	2 (4.9%)	32 (78%)	3 (7.3%)
17	Tomato farmers used in appropriate containers (sharp-edged) in handling their produce	0 (0%)	4 (9.8%)	1 (2.4%)	33 (80.5%)	3 (7.3%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.4.2 Responses of Tomato Farmers

In respect to the causes of post-harvest loss of tomatoes faced by tomato farmers in some selected Districts in the Upper West Region of Ghana, majority of the respondents (75.6%) agreed that they face massive losses in their tomato production with few of them indicating that they strongly agreed (7.3%), strongly disagreed (4.9%), disagreed (9.8%) and just (2.4%) remaining undecided.

With regards to the causes of post-harvest losses by the infestation of pests and diseases, (73.2%) constituting majority of the farmer respondents agreed to the fact that tomato loss occur through pests and disease infestation, (7.3%) strongly disagreed, whereas (2.4%) strongly disagreed, (19.5%) disagreed and (2.4%) remained undecided that tomato losses occur through infestation of pests and diseases.

Again, majority (68.3%) of the sampled respondents expressed agreement with the assertion that there is lack of financial support to tomatoes farmers with (22%) of the farmers strongly in agreement whereas (9.7) % disagreed to the statement.

With respect to providing support to tomato farmers, majority (75.6%) of the respondents agreed with (12.2%) also strongly in agreement that tomato farmers do not receive technical support services, whereas (7.3%) disagreed to the statement.

When asked on whether tomato farmers receive low prices for their harvested produce, most (70.7%) of the sampled respondents agreed to that assertion and (14.6%) strongly agreed in contrast to (2.4%) and (9.8%) strongly disagreeing and disagreeing with (2.4%) remaining undecided.

Responding to statement as to whether there is limited available ready market for tomato farm produce, most (82.9%) of the sampled respondents agreed with the statement with just (7.3%) disagreeing and (2.4%) remaining undecided.

In a response to a statement that tomato farmers have inadequate storage facilities, most (73.2%) of the respondents agreed, (2.2%) strongly agreed, and 4.9% remained undecided.

On whether tomato farmers have inadequate storage technology, 80.5% of the respondents answered in affirmation (agreed), 17.1% strongly agreed and 4.9% remained undecided.

On the issue of whether tomato farmers do not have fair knowledge on modern farming practices, 73.2% of respondents agreed, 12.2% strongly agreed, 4.9% strongly agreed, 7.3% disagreed and 2.4% remained undecided.

On the assertion that there are inadequate processing plants/ factories for tomato produce, majority (65.9%) of the sampled respondents agreed, 29.3% strongly disagreed, 2.4% disagreed and 2.4% remained undecided.

Regarding the issue of harvest tomatoes having singular use, 41.5% of the participants agreed, 7.3% strongly agreed and 39% disagreed with the statement with just 12.2% remaining neutral.

On whether tomato farmers used genetically modified seeds, 2.4% strongly disagreed, 46.3% disagreed, 24.4% agreed, 4.9% strongly disagreed and 22% were neutral.

With regard to the issue of tomato farmers fumigating their tomato plants/farms, 4.9% strongly disagreed, 43.9% disagreed, 24.4% agreed, 4.9% strongly agreed and 22% remained neutral.

On whether the variety of tomato seeds used by farmers lead to post-harvest losses, 4.9% strongly disagreed, 17.1% disagreed, 65.9% (majority) agreed, 7.3% strongly agreed and 4.9% remained neutral.

Majority (75.6%) of the respondents agreed and 17.1% strongly agree that tomato produce have peak and off-peak season, while 7.3% disagreed.

On whether tomato farmers used inappropriate tools in harvesting their produce, majority (78%) of the study participants agreed and 7.3% disagreed, while 2.4% strongly disagreed, 7.3 disagreed and 4.9% remained undecided.

With regards to tomato farmers using inappropriate containers (sharp-edged) in handling their produce, most (80.5%) of the participants agreed and 7.3% strongly agreed with the statement, whereas only 9.8% disagreed and 2.4% remained neutral.

The study revealed the following as causes of post-harvest loss of tomatoes:

i. Transportation as a result of poor road network
ii. Lack of processing facilities to can and preserve them
iii. Inadequate irrigation facilities to support production
iv. Diseases and pests infestations
v. Farmers producing tomatoes at the same time or period for the same market leading to excessive glut of the produce
vi. High transportation cost
vii. Longer distances between farms and market centres
viii. Lack of technical know-how on tomato production
ix. Lack of proper storage system
x. Inadequate knowledge in the application or utilization of chemicals for pests and disease control or prevention.

The above-mentioned causes are described by Anaba (2018) as factors that drive post-harvest loss of tomatoes. Issahaku (2012) supports that claim that close to fourth-fifths of post-harvest loss of tomatoes occur due to inappropriate handling practices such as inappropriate storage system. From the study, it can be inferred that foreign varieties of tomatoes meant for local cultivation must be critically evaluated for its adaptation to the local environment before their acceptance for cultivation by farmers (Adu-Dapaah & Oppong-Konadu, 2002). In fact, Nyamah *et al.* (2014) observes that poor adaptation of foreign variety of tomatoes for local cultivation could put much environmental and temperature, drought, disease and pest stress on the produce to warrant their early losses. Yeboah (2011) reaffirmed that claim that poor roads, lack of proper storage systems and insects attack. This claim is also authorised by Kodjogbe *et al.* (2006) that poor transportation, irrigation and storage systems are attributed to post-harvest loss of tomatoes.

4.5 Causes of Post-Harvest Losses of Tomato Faced by Tomato Retailers

The causes identified by tomato retailers ranges from financial constraints, education (illiteracy), poor road network, inappropriate transport systems among others as seen in table 4.4.

Table 4.5: Causes of Post-Harvest Loss of Tomatoes Faced by Tomato Retailers in the Food Value Chain in Some Selected Districts in the Upper West Region of Ghana

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	I faced massive losses in my tomato retailing business	0 (0%)	0 (0%)	1 (1.8%)	52 (91.2%)	4 (7%)
2	These losses occur through mechanical damages and bruises caused by bad packaging and bad nature of roads	0 (0%)	1 (1.8%)	2 (3.5%)	49 (86%)	5 (8.8%)
3	There is lack of financial support to tomatoes retailers	0 (0%)	11 (19.3%)	15 (26.3%)	28 (49.1%)	3 (5.3%)
4	Retailers do not receive technical support services	0 (0%)	0 (0%)	1 (1.8%)	52 (91.2%)	4 (7%)
5	Tomato retailers buy produce from farmers at high prices	1 (1.8%)	13 (22.8%)	13 (22.8%)	25 (43.9%)	5 (8.8%)
6	Tomato retailers sell produce to customers in the market centres at low prices.	0 (0%)	8 (14%)	4 (7%)	36 (63.2%)	9 (15.8%)
7	There is limited available ready market for tomato produce.	0 (0%)	2 (3.5%)	10 (17.5%)	40 (70.2%)	5 (8.8%)
8	Tomato retailers have inadequate storage facilities	0 (0%)	5 (8.8%)	8 (14%)	38 (66.7%)	6 (10.5%)
9	Tomato retailers have inadequate storage technology	1 (1.8%)	1 (1.8%)	6 (10.5%)	42 (73.7%)	7 (12.3%)
10	Harvested tomatoes have singular use	1 (1.8%)	4 (7%)	11 (19.3%)	34 (59.6%)	7 (12.3%)

11	Tomato retailers used inappropriate containers (sharp-edged) in handling their produce	0 (0%)	3 (5.3%)	12 (21.1%)	36 (63.2%)	6 (10.5%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.6 Responses of Tomato Retailers

With respect to the causes of post-harvest loss of tomatoes faced by tomato retailers in some selected districts in the Upper West region of Ghana, majority (91.2%) of the retailer respondents agreed that they face massive losses in their tomato retailing business with few of them indicating that they strongly agree (7%), and just 1.8% remaining undecided.

With regard to the causes of post-harvest loss of tomato through poor packaging systems and bad nature of the roads, 86% (majority) of the retailer respondents admitted that mechanical damage and bad road network caused greater loss to them in their tomato business, 8.8% strongly disagreed, whereas 1.8% disagreed and 3.5% remained undecided.

Again, 49.1% of the sampled respondents expressed agreement with the assertion that there is lack of financial support to tomatoes retailers and 5.3% strongly agreed, with 19.3% indicating disagreement and 26.3% remaining neutral.

As one of the causes of post-harvest loss of tomatoes, majority (91.2%) agreed and 7% also strongly agreed that tomato retailers do not receive technical support services, whereas 1.8% remained undecided.

On whether tomato retailers buy tomatoes at high prices from farmers, 43.9% of the sampled respondents agreed and 8.8% strongly agreed in contrast to 1.8% strongly disagreeing and 22.8% disagreeing with 22.8% remaining undecided.

As regards the sale of tomato by retailers to customers at low prices, majority (63.2%) of the respondents agreed and 15.8% strongly with the assertion, contrary to 14% disagreeing and 7% remaining neutral.

On whether there is limited available ready market for tomato farm produce, most (70.2%) of the sampled respondents agreed with the statement with just 3.5% disagreeing and 17.5% remaining undecided.

In a response to a statement that tomato retailers have inadequate storage facilities, most (66.7%) of the respondents agreed, 10.5% strongly agreed, 8.8% disagreed and 14% remained undecided.

On whether tomato retailers have inadequate storage technology, 73.7% of the respondents answered in affirmation (agreed), 12.3% strongly agreed, 1.8% strongly disagreed, 1.8% disagreed and 10.5% remained undecided.

Regarding the issue of harvesting tomatoes having singular use, 59.6% of the participants agreed, 12.3% strongly agreed, 1.8% strongly disagreed and 7% disagreed with the statement with just 19.3% remaining neutral.

With regards to tomato retailers using inappropriate containers (sharp-edged) in handling their produce, most (63.2%) of the participants agreed and 10.5% strongly agreed with the statement, whereas only 5.3% disagreed and 21.1% remained neutral.

It is established from the study that retailers incur a lot of losses through mechanical damage as a result of poor packaging and bad nature of the roads. Improper packaging of tomatoes coupled with undulating nature of the roads and the long distances to be covered with already ripped harvested tomatoes causes post-harvest loss of the tomato fruit. Hailu & Derbew (2015) supported this revelation when they noted that poor temperature management, mechanical damage, microbial action and poor packaging are some of the major causes of post-harvest loss of fresh fruits and vegetables. The usage of inappropriate containers with sharp edges by retailers to package tomatoes can easily lead to overcrowding of tomatoes, create holes and punctures on the crop which eventually leads to great water loss.

Results from the study also revealed that one of the major causes of post-harvest loss of tomatoes among retailers in the study area is the absence of readily available market for the produce. About 78% of tomato retailers affirmed that there is limited available ready market for the produce which is highly susbjectible to deterioration. In affirmation, Yandiji *et al.* (2011) noted that the tomato fruit after harvest continue to respire and live as a living tissue until consumption or deterioration takes place. This explains why keeping the produce in the market for longer periods before sales will eventually lead to substantial losses as its quantity and quality will be highly compromised. Orzolek *et al*. (2006) contended to this findings in a similar studies by indicating that the production of tomatoes is labour intensive and as such should be harvested in a matured vine-ripped state in order to prevent the produce from becoming overly ripped for easy transportation and marketing to the final consumer.

The study also revealed that one of the cause of post-harvest loss of tomato among retailers is lack of technical and financial support from technocrats and well-meaning organizations. A good number of the tomato retailers agreed that they receive no support from any source. This is a major cause of post –harvest loss. Gustavsson *et al.* (2011) affirmed that in developing countries, the cause of post-harvest loss is mainly connected to financial, managerial and technical limitations as compared to developed countries where the causes are related to quality standards and consumer behaviour.

4.7 Challenges of Post –Harvest loss of Tomatoes Faced by Farmers and Retailers in Selected Districts in the Upper West Region

The challenges of post-harvest loss of tomatoes faced by farmers and retailers ranges from financial, technical, storage, access to market, improper packaging among others as revealed by table 4.5.

Table 4.6: Challenges of Post-harvest Losses of Tomatoes among Farmers in selected Districts in the Upper West region of Ghana

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	There are varied challenges facing tomato farmers	2 (4.9%)	3 (7.3%)	0 (0%)	32 (78%)	4 (9.8%)
2	There is lack of effective irrigation facilities for tomato farmers	0 (0%)	3 (7.3%)	0 (0%)	37 (90.2%)	1 (2.4%)
3	Tomato farmers are faced with a lot of pests and diseases infections	1 (2.4%)	2 (4.9%)	0 (0%)	35 (85.4%)	3 (7.3%)
4	Farmers produce tomatoes in insufficient quantities	2 (4.9%)	16 (39%)	2 (4.9%)	17 (41.5%)	2 (9.8%)
5	Locally produced tomatoes are of low quality relative to imported ones	0 (0%)	6 (14%)	1 (2.4%)	33 (80.5%)	1 (2.4%)
6	Farmers harvest tomato produce at the inappropriate stage/period	0 (0%)	7 (17.1%)	6 (14.6%)	25 (61%)	3 (7.3%)
7	Most farmers do harvest their tomato produce under excessive field heat.	0 (0%)	1 (2.4%)	4 (9.8%)	35 (85.4%)	1 (2.4%)
8	Farmers of tomatoes lack the necessary storage facilities.	0 (0%)	1 (2.4%)	2 (4.9%)	28 (68.3%)	10 (24.4%)
9	Farmers uses inappropriate packaging materials in transporting their tomatoes	1 (2.4%)	11 (26.8%)	4 (9.8%)	24 (58.5%)	1 (2.4%)
10	Tomatoes farmers harvest their produce under poor/bad field sanitation	1 (2.4%)	6 (14.6%)	4 (9.8%)	25 (61%)	5 (12.2%)

11	Farmers used inappropriate means of transport in transporting tomato produce to markets.	1 (2.4%)	9 (22%)	3 (7.3%)	27 (65.9%)	1 (2.4%)
12	There are poor/bad transportation networks from tomato farms to market canters	0 (0%)	0 (0%)	1 (2.4%)	26 (63.4%)	14 (34.1%)
13	Tomato Farmers are faced with the problem of reliable market for their farm produce	0 (0%)	0 (0%)	0 (0%)	30 (73.2%)	11 (26.8%)
14	Tomato farmers lack technical knowledge and support from technocrats.	0 (0%)	0 (0%)	2 (4.9%)	30 (73.2%)	9 (22%)
15	Farmers do sell their tomato produce right on the farm to traders	1 (2.4%)	6 (14.6%)	5 (12.2%)	23 (56.1%)	6 (14.6%)
16	Tomatoes sold on the farms command low prices	2 (4.9%)	7 (17.1%)	3 (7.3%)	21 (51.2%)	8 (19.5%)
17	Farmers face high cost of production of tomatoes	0 (0%)	2 (4.9%)	3 (7.3%)	33 (80.5%)	3 (7.3%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.8 Responses from Farmers on Challenges of Post-harvest Loss of Tomatoes

In respect of the challenges of post-harvest losses of tomatoes in some selected Districts in the Upper West Region of Ghana, majority (78%) of the sampled respondents agreed with the assertion that there are varied challenges facing tomato farmers with 9.8% of them in strong agreement, while 4.9% strongly disagreed and 7.3% disagreed.

On whether there is lack of effective irrigation facilities for tomato farmers, 90.2% of respondents agreed, 2.4% strongly agreed, whereas 7.3% disagreed.

As regards the issue of tomato farmers faced with a lot of pests and diseases infections, 85.4% (majority) of the sampled participants agreed that pests and diseases invade tomato farms, 7.3% strongly agreed, 2.4% strongly disagreed and 4.9% disagreed.

On the assertion that farmers harvest tomato produce at inappropriate stage/period, 41.5% of the respondents agreed, 9.8% strongly agreed, 4.9% strongly disagreed, 39% disagreed with 4.9% staying neutral.

Regarding the issue of locally produced tomatoes being of low quality relative to imported ones, majority (80.5%) of the sampled respondents agreed, with few of them either strongly agreeing (2.4%), disagreeing (14%) or remaining neutral (2.4%).

More importantly, majority (61%) of the study participants agreed and 7.3% strongly agreed with the statement that farmers harvest tomato produce at the inappropriate stage/period, whereas 17.1% completely disagreed and 14.6% remained undecided**.**

Most (85.4%) of the farmer respondents agreed with the statement that most farmers do harvest their tomato produce under excessive field heat with few (2.4%) strongly agreeing, while 2.4% disagreed and 9.8% remained neutral.

Concerning the issue of tomato farmers lacking the necessary storage facilities, most (68.3%) of the farmer respondents agreed with the statement, 24.4% of strongly agreed, contrary to 2.4% showing disagreement and 4.9% of them remaining neutral.

On the issue of farmers using inappropriate packaging materials in transporting their tomatoes, most (58.5%) of the respondents stated that they agreed with that assertion, whereas 2.4% strongly agreed, 2.4% strongly disagreed, 26.8% disagreed and 9.8% remained neutral.

On whether tomato farmers harvest their produce under poor/bad field sanitation, most (61%) of the sampled participants of this study expressed agreement, 12.2% expressed strong agreement, whereas 2.4% strongly disagreed, 14.6% disagrees and 9.8% remained undecided.

On whether farmers used inappropriate means of transport in transporting tomato produce to markets, majority (65.9%) of the respondents agreed with that assertion, 2.4% strongly agreed, while 2.4% strongly disagreed, 22% disagreed and 7.3% remained neutral.

With regard to the statement that there are poor/bad transportation networks from tomato farms to market canters, 63.4% (most) of the sampled respondents indicated agreement, 34.1% showed strong agreement, 2.4% remained undecided with no indication of disagreement or strong disagreement.

Regarding the statement that tomato farmers are faced with the problem of reliable market for their farm produce, majority (73.2%) of the respondents agreed to that assertion and 26.8% expressed strong agreement to the statement with no sign of disagreement.

In respect of the issue on whether tomato farmers lack technical knowledge and support from technocrats, most (73.2%) of the participants expressed agreement and 22% strongly agreed with just 4.9% remaining neutral.

Concerning the assertion that farmers do sell their tomato produce right on the farm to traders, 56.1% of the respondents agreed, 14.6% strongly agreed, while 2.4% strongly disagreed, 14.6% disagreed and 12.2% remained neutral.

As whether tomatoes sold on the farms command low prices, 51.2% agreed, 19.5% strongly agreed, while 4.9% strongly disagreed, 17.1% disagreed and 7.3% remained undecided.

On whether farmers face high cost of production of tomatoes, majority (80.5%) of the sampled respondents agreed, 7.3% strongly disagreed, whereas only 4.9% disagreed and 7.3% remained undecided.

The study established the claim that indeed tomato farmers and retailers (71% to 78%) are faced with numerous challenges. These challenges range from lack of effective irrigation facilities for tomato farmers, pests and diseases infestations, insufficient production of tomatoes during lean season, low quality of locally produced tomatoes, lack of storage facilities, the use of inappropriate packaging materials for transporting tomatoes, inappropriate means of transporting the produce, bad transportation networks, long distance between farms and marketing centres, problem of reliable market for their farm produce, high cost of production of tomatoes and low price of produce during peak season. These challenges are also identified by Yeboah (2011) and Anaba (2018) that whenever tomatoes are transported on bad roads, particularly in tropical regions, they decompose at a faster rate than those transported on good roads on cold regions. Idah *et al.* (2007) support the claim that poor roads cause vehicle vibrations and inappropriate packaging of produce leads to

mechanical damage of the produce. On storage system, Kitinoja *et al.* (2009) confirmed the finding that farmers and retailers lack proper storage amenities to store their tomato produce in readiness for sale.

It is important to note that a significant number of farmers need support in terms of storage, access to ready market and technical support to derived maximum benefit from tomato cultivation.

Table 4.7: Challenges Faced by Tomatoes Retailers in Some Selected Districts in the Upper West Region of Ghana

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	There are varied challenges facing tomato retailers	0 (0%)	2 (3.5%)	9 (15.8%)	41 (71.9%)	4 (7%)
2	There is always shortage of tomato supply in the market centres during lean season	0 (0%)	6 (10.5%)	16 (28.1%)	27 (47.4%)	8 (14%)
3	Tomato retailers are faced with a lot of pests and diseases infections	1 (1.8%)	1 (1.8%)	6 (10.5%)	42 (73.7%)	7 (12.3%)
4	Locally produced tomatoes are of low quality relative to imported ones and as a result do not sell fast	0 (0%)	4 (7%)	10 (17.5%)	33 (57.3%)	10 (17.5%)
5	Tomatoes are harvested at inappropriate stage/period	2 (3.5%)	5 (8.8%)	13 (22.8%)	32 (56.1%)	5 (8.8%)
6	Tomato retailers lack the necessary storage facilities.	1 (1.8%)	5 (8.8%)	8 (14%)	38 (66.7%)	5 (8.8%)
7	Retailers use inappropriate packaging materials in transporting tomatoes to the market centres	2 (3.5%)	2 (3.5%)	13 (22.8%)	33 (57.9%)	7 (12.3%)
8	Retailers use inappropriate means of transport in transporting tomato produce to markets.	1 (1.8%)	6 (10.5%)	14 (24.6%)	31 (54.4%)	5 (8.8%)
9	There are poor/bad transportation networks from tomato farms to market centres	0 (0%)	0 (0%)	10 (17.5)	42 (73.7)	5 (8.8%)
10	Retailers are faced with the problem of unreliable market of tomatoes	0 (0%)	1 (1.8%)	6 (10.5%)	42 (73.7%)	8 (14%)

11	Tomato farmers lack technical knowledge and support from technocrats.	0 (0%)	0 (0%)	4 (7%)	46 (80.7%)	7 (12.3%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.9 Responses from Retailers on Challenges of Post-harvest Loss of Tomatoes

In respect of challenges of post-harvest losses of tomatoes faced by retailers in the Upper West region of Ghana, majority (71.9%) of the sampled respondents agreed with the assertion that there are varied challenges facing tomato retailers with 7% of them in strong agreement, while 3.5% disagreed and 15.8% were undecided.

On whether there is always shortage of tomato supply in the market centres during lean season, 47.4% of the respondents agreed and 14% strongly agreed, while 10% disagreed and 28.1% were undecided.

As regards the issue of tomato retailers faced with a lot of pests and diseases infections, 73.7% (majority) of the sampled participants agreed, 12.3% strongly agreed, 1.8% strongly disagreed, 1.8% disagreed and 10.5% were undecided.

On the assertion that locally produced tomatoes are of low quality relative to imported ones and as a result do not sell fast, 57.3% (majority) of the respondents agreed, 17.5% strongly agreed, 7% disagreed and 17.5% stayed neutral.

Majority (56.1%) of the study participants agreed and 8.8% strongly agreed, whereas 3.5% strongly disagreed, 8.8% disagreed and 22.8% remained neutral that tomatoes are harvested at inappropriate stage/period.

Concerning the issue of tomato retailers lacking the necessary storage facilities, 66.7% (majority) of the retailer respondents agreed, 8.8% of strongly agreed, contrary to 1.8% strongly disagreeing, 8.8% disagreeing and 14% of them remaining neutral.

On the issue of retailers using inappropriate packaging materials in transporting their tomatoes, 57.9% (majority) of the respondents stated that they agreed and 12.3% strongly agreed, whereas 3.5% strongly disagreed3.5% disagreed and 22.8% remained neutral.

On whether retailers used inappropriate means of transport in transporting tomato produce to markets, majority (54.4%) of the respondents agreed with that assertion, 8.8% strongly agreed, while 1.8% strongly disagreed, 10.5% disagreed and 24.6% remained neutral.

As regards the statement that there are poor/bad transportation networks from tomato farms to market centres, 73.7% (most) of the sampled respondents indicated in agreement, 8.8% strongly agreed, 1.8% disagreed and 10.5 % remained undecided.

Regarding the statement that tomato retailers are faced with the problem of reliable market for their produce, majority (73.7%) of the respondents showed agreement and 14% expressed strong agreement, 1.8% disagreement and 10.5% were neutral.

In respect of the issue on whether tomato retailers lack technical knowledge and support from technocrats, most (80.7%) of the participants expressed agreement and 12.3% strongly agreed with just 7% remaining neutral.

Findings from the study revealed that majority of the retailers faced a lot of challenges in their tomato retailing business. Retailers indicated that they mostly run out of business during lean seasons as tomato cultivators becomes few as a result of lack of irrigational facilities for farmers to practice dry season tomato cultivation since the Upper West Region is noted for only one major raining season. To boost production and supply of tomatoes all year run, financial and technical assistance needs to be given to tomato producers in the area.

Regarding the quality of locally produced tomatoes to that of imported ones, majority of the retailers affirmed to the assertion that locally produced tomatoes are inferior when compared with imported tomatoes from neighbouring countries like Burkina Faso. Kodjogbe *et al*. (2010) confirmed in a related studies that one of the major challenges among tomato cultivators is the usage of indigenous seeds/ self-propagated

seeds. Improved variety of tomato seeds need to be used to reduce the challenges encountered by tomato handlers in the study area. MOFA (2008) on the contrarily indicated that there are a number of varieties of tomato seedlings. The availability of wide range of varieties gives farmers and consumers the opportunity to choose from.

In relation to the harvesting periods for tomatoes, retailers revealed that tomatoes are often bought from farmers in an already reddish ripped state. Harvesting tomatoes when they are fully ripped in the reddish state is inappropriate especially when they are not to be consumed within the shortest period of time. This is as a result of the slow nature of the tomato business in the market as there is no readily available market for the produce. The longer distances of travel and poor nature of the roads delay the produce before it finally arrives. Beckles (2012) affirmed that the period and time of harvest is crucial in attaining greater quality of the tomato fruit.

Arah *et al.* (2012) confirmed that the tomato produce can be harvested in either a matured green, partially ripped or in the ripped stage. Harvesting them in a matured green and partially ripped state are for producers targeting long distances of travel.

With regards to transportation used by retailers to transport tomatoes, majority of the respondents agreed that there poor transportation systems used to convey produce to marketing centres. The use of vehicular trucks, tricycles and many other inappropriate transport systems can easily break along the journey. Also many of these transport systems are not enclosed exposing the produce to other external hazards, sunshine and rain fall. Similar findings by Ajagbe *et al.* (2014) revealed that tomato handlers constantly transport their produce to market centres using pick-up van, motor cycles and trucks with a handful of them using their cars. Muhamma *et al.* (2012) however opined that tomatoes should be conveyed in a well-ventilated vehicle with a cover at the top to avoid direct sunlight, safety from rainfall and other hazards. In affirmation,

Hurst (2010) added that in the course of transportation, the produce should be properly packed and stacked to avoid excessive movement and vibration.

Results from the study also revealed that retailers lacked storage facilities to keep their tomatoes in an already slow movement business system. No storage facilities and space to keep their produce. Most of them display the produce in the sun with its associated heat and dust increasing perishability rate. About 70% of the retailers affirmed that they lack storage space and facilities to keep their produce without compromising quality and quantity. In light of this, Kitinoja *et al*. (2009) reported that there are lack of storage materials at the farms, wholesale and retail level coupled with lack of ventilation and cooling vans in developing countries. Tomato retailers needs adequate support in terms of provision of storage space and logistics to be in the tomato business.

4.10 Common Tomato Treatment Methods used by Tomato Retailers

Treatment methods that can be used by tomato handlers to minimize post-harvest losses and reduce the challenges faced by tomato farmers and retailers in some selected Districts in the Upper West region of Ghana are indicated in table 4.7.

Table 4.8: Treatment Methods that can be used by Tomato Farmers to Minimize Post-Harvest Loss

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	There are various treatment methods of tomatoes	2 (4.9%)	4 (9.8%)	7 (17.1%)	25 (61%)	3 (7.3%)
2	Tomato farmers freeze their produce before selling	5 (12.2%)	23 (56.1%)	7 (17.1%)	5 (12.2%)	1 (2.4%)
3	There are many processing factories that canned tomato produce in my district	2 (4.9%)	23 (56.1%)	8 (19.4%)	8 (19.5%)	0 (0%)
4	Farmers adopt sun drying as a treatment method of preserving tomatoes	1 (2.4%)	7 (17.1%)	8 (19.5%)	23 (56.1)	2 (4.9%)
5	Farmers in my district are familiar with edible coating as a treatment method of preserving tomatoes	1 (2.4%)	25 (61%)	11 (26.8%)	4 (9.8%)	0 (0%)
6	Irradiation is commonly used as a treatment method of tomatoes in my district	0 (0%)	19 (46.3%)	9 (22%)	11 (26.8%)	2 (4.9%)
7	Farmers are conversant with chemical (sodium hypo chloride) treatment as another alternative of preserving tomatoes	5 (12.2%)	27 (65.9%)	4 (9.8%)	4 (9.8%)	1 (2.4%)
8	Tomatoes farmers have been using gaseous treatment as another method of preserving tomatoes.	6 (14.6%)	23 (56.1%)	5 (12.2%)	7 (17.1%)	0 (0%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.11 Responses on Treatment Methods among Tomato Farmers

Concerning the common treatment methods used by tomato farmers to minimize post-harvest losses among tomato farmers in the selected Districts in the Upper West Region of Ghana, majority (61%) of the farmer respondents agreed that there are various treatment methods of tomatoes, whereas 7.3% strongly agreed, 4.9% strongly disagreed, 9.8% disagreed, 7.3% strongly agreed and 17.1% remained neutral.

When asked whether tomato farmers freeze their produce before selling, 56.1% (majority) of the farmer respondents disagreed, 12.2% strongly disagreed, whereas 12.2% agreed, 2.4% strongly agreed and 17.1% remained undecided that tomato farmers freeze their produce before selling.

Again, majority (56.1%) disagreed that there are many processing factories that processed tomato produce in their district, with 4.9% strongly in disagreement, whilst 19.5% agreeing and 19.4% remaining neutral.

Majority (75.6%) of the sampled respondent agreed and 12.2% also strongly agreed that farmers adopt sun drying as a treatment method of preserving tomatoes, while 24.% strongly disagreed.

Regarding farmers in my district becoming familiar with edible coating as a treatment method of preserving tomatoes, majority (61%) disagreed and 2.4% strongly disagreed, while 9.8% agreeing and 26.8% remaining neutral.

On matters of irradiation being a common treatment method of tomatoes in my district, 46.3% disagreed, whereas 26.8% agreed, 4.9% strongly agreed with 22% remaining neutral.

Regarding tomato farmers becoming conversant with chemical (sodium hypo chloride) treatment as another alternative of preserving tomatoes, 65.9% agreeing, 12.2% strongly agreeing, 9.8% agreeing, and 2.4% remained undecided.

When inquired as to whether tomato farmers use gaseous treatment as another method of preserving tomatoes, 14.6% strongly disagreed, 56.1% disagreed, whilst 17.1% agreed and only 12.2% remained neutral.

Freezing of tomatoes is one of the best treatment methods that can be used to enhance the shelf life of the produce but not practice in the study area as indicated by majority of the respondents**.** This finding is in contradiction with the works of Deribe, Beyene and Beyene (2016) which revealed that cool temperature has been found to be the most important factor in maintaining product quality since it has the potential of increasing the storage life of the produce by reducing respiration level, lessen sensitivity to ethylene gas and minimizing water loss.

The fallout regarding the establishment of tomato processing factories for the produce is supported by similar findings by Yeboah (2011), FAO and INPhO (1998) who stated that no matter the publicity given to tomato and its products, if there is no effort by the major stakeholders to help tomato farmers and traders by establishing and encouraging community based processing facilities nothing significant can be attained.

The study established the drying technique as one of the treatment methods of tomato, such that drying as a treatment method preserves tomatoes before sales. Related findings by Ashby (2005) described the drying method as steaming or dipping ripe tomatoes into hot water to slacken skin, chill in cold water, peel and slice into pieces about ¾ inch wide, lighten for three minutes and dry in the dehydrator for 10 – 18 minutes or twice this time using the conventional oven.

The fallout of this study also established that tomato farmers and retailers are not familiar with edible coating as a treatment method of preserving tomatoes since majority (61%) of them indicated their unfamiliarity with that preservation method. This finding is similar to the

irradiation method which the farmers are not conversant with. This position is reaffirmed by just 26.8% of the respondents who claim that they agreed with this method, whereas 46.3% of them totally disagreed.

The study also established that tomato farmers are not conversant with chemical (sodium hypo chloride) treatment as alternative method of preserving tomatoes. This is translated in the response of the study participants (65.9%) that they disagreed with the statement that farmers are conversant with chemical (sodium hypo chloride) treatment as another alternative of preserving tomatoes. Findings from this study also revealed that tomato farmers are not conversant with gaseous treatment as a method of preserving tomatoes because 56.1% of the respondents expressed disagreement to having knowledge of it being used as a treatment method.

Table 4.9: Treatment Methods that can be used by Tomato Retailers to Minimize Post-Harvest Loss in Some Selected Districts in the Upper West Region of Ghana

No.	Questionnaire Item	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 3	Strongly Agree 5
1	There are various treatment methods of tomatoes	0 (0%)	3 (5.3%)	9 (15.8%)	41 (71.9%)	4 (7%)
2	Tomato retailers freeze their produce before selling	1 (1.8%)	18 (35.1%)	20 (31.6%)	14 (24.6%)	4 (7%)
3	Retailers are familiar with edible coating as a treatment method of preserving tomatoes	2 (3.5%)	12 (56.1%)	8 (19.4%)	8 (19.5%)	0 (0%)
4	Retailers use irradiation method in treatment method of tomatoes before selling	3 (5.3%)	27 (47.4%)	16 (28.1%)	11 (19.3%)	0 (0%)
5	Retailers are conversant with chemical (sodium hypo chloride) treatment as another alternative for preserving tomatoes	5 (8.8%)	26 (45.6%)	17 (29.8%)	8 (26.8%)	2 (4.9%)
6	Tomatoes retailers have been using gaseous treatment as another method of preserving tomatoes.	5 (12.2%)	27 (65.9%)	4 (9.8%)	4 (14%)	1 (1.8%)

SA = Strongly Agree, A = Agree, U = Undecided, D = Disagree, SD = Strongly Disagree

4.12 Responses on Treatment Methods among Tomato Retailers

Regarding the treatment methods and strategies that can be used by tomato handlers (retailers) to minimize post-harvest losses and reduce the challenges faced by tomato retailers in some selected Districts in the Upper West Region of Ghana, majority (61%) of the respondents agreed that there are various treatment methods of tomatoes, whereas 7.3% strongly agreed, 4.9% strongly disagreed, 9.8% disagreed, 7.3% strongly agreed and 17.1% remained neutral.

As regards to whether tomato farmers freeze their produce before selling, 24.6% of the retailer respondents agreed, and 7% strongly agreed, whereas 1.8% strongly disagreed, 35.1% disagreed and 31.6% remained undecided.

Regarding retailers being familiar with edible coating as a treatment method of preserving tomatoes, 19.5% agreed, whereas 5.3% strongly disagreed, 47.4% disagreed and 28.2% remained neutral.

On matters of irradiation being used by retailers as a treatment method of tomatoes before selling, 19.3% agreed, whereas 5.3% strongly disagreed, 47.6% disagrees with 28.1% remaining neutral.

Regarding tomato retailers becoming conversant with chemical (sodium hypo chloride) treatment as another alternative for preserving tomatoes, 26.8% agreed, 4.9% strongly agreed, while 8.8% strongly disagreed, 45.6% disagreed and 29.8% remained undecided.

As regards the issue of tomato retailers using gaseous treatment as another method of preserving tomatoes, 14% agreed, 1.8% strongly disagreed, whilst 12.2% strongly disagreed, 65.9% (majority) disagreed and 1.8% remained neutral.

The study established that about 70% of tomato retailers admitted that there are various treatment methods of tomatoes to minimised or stop spoilage. Findings from the study revealed that most retailers do not practice freezing as a method of preserving tomatoes for lack of facilities.

With reference to the use of edible coating as a treatment method, majority of the retailers (about 60%) do not practice it because they do not have the requisite skills and facilities to do so and same thing applied to the use of irradiation and the use of sodium hypo chloride. In affirmation, majority of the retailers practice sun drying of tomatoes in the study area. This goes to confirm that sunshine is readily available and accessible to all. Swetha & Banothu (2018) contended that the application of emerging technologies such as irradiation, heat treatment, chemical, modified atmosphere packaging and refrigeration to preserve tomatoes and extend the shelf life is paramount.

Qualitative Data Analysis

4.13 Results/Findings for Objective One:

4.13.1 Interview Responses from Agriculture Extension Officers

The objective one of the study sought to identify the post-harvest handling practices of tomatoes by farmers and retailers in some selected Districts in the Upper West Region of Ghana by providing the Agriculture Extension Officers' responses to the question: *What are the post-harvest handling practices of tomatoes by farmers and retailers in the selected Districts in Upper West region of Ghana?*

Agriculture Extension Officer "A" – Wa Municipal

i. When asked of the special focus the Ministry of Agriculture has on tomato production, the participant indicated the *government through the Ministry of*

Agric hopes to prevent importation of tomatoes into the country so it is doing its best to boost tomato production in the district by supporting farmers with fertilizers and farming inputs to realize this dream. He further stated that the *aim of the Ministry is to increase tomato production through the AEAs*.

ii. On whether the Ministry has any record on tomato production in the region, the participant indicated that *Yes, it has.*

iii. When asked how the Ministry rate tomato production in the district/region, the participant stated that *tomato production is on the rise* within the catchment area. He further indicated that *the region cannot be fed perfectly because the Ministry is averagely ok with tomato production.*

iv. On whether all the tomatoes consumed in the study area are cultivated within the region, the participant clearly indicated that *No, because others are transported for use.*

v. When asked on the post-harvest handling practices used by farmers and retailers in the area *the participant indicated that farmers harvest their tomato produce at any time of the day, pack them in any available container(bucket, basins, baskets) for transport and mostly used any available means of transport (motor cycles, motor bycicles, kia trucks etc) irrespective what consequences it may have on the produce*

vi. When asked of the best post-harvest handling practices of tomatoes that can be employed by farmers and retailers in the study area to reduce post-harvest losses, the participant stated that *some of the measures that can be done by the District to reduce post-harvest losses are early morning harvesting of produce or harvesting in the late hours of the evening where there is no field heat, appropriate packaging and transport of produce and sorting and grading of produce.*

Agriculture Extension Officer "B" – Wa West District

a. When asked of the special focus the Ministry of Agriculture has on tomato production, the participant indicated *agronomy factors of tomato production, provision of affordable water for irrigation such as construction of dug-outs and dams to supply farmers all year round.*

b. On whether the Ministry has any record on tomato production in the region, the participant indicated that *Yes.*

c. When asked how the Ministry rate tomato production in the district/region, the participant stated that the rate of *tomato production in the district is 30% both in the raining and dry seasons.*

d. On whether all the tomatoes consumed in the study area are cultivated within the region, the participant clearly indicated that

I cannot conclude that all the tomatoes consumed are cultivated in the area because during the wet season, the district/region can produce enough for its own consumption due to the presence of water in the existing dam and dug-outs, while the district or the region may rely on tomatoes from elsewhere to supplement local consumption during the lean (dry) season because there are inadequate irrigation facilities. Sometimes, there will even be gluts: farmers are able to produce more than what the district/region can consume during the major raining season and some will even go waste.

e. When asked on the post-harvest handling practices used by farmers and retailers in the area *the participant indicated that tomatoes are mostly harvested in a matured ripped state, not cleaned nor sorted before transporting. This increases their perishability rate as the road network leading to market centres are very deplorable.*

f. When asked of the best post-harvest handling practices of tomatoes that can be employed by farmers and retailers in the study area to reduce post-harvest losses, the participant stated that *when farmers and retailers are trained on the best ways of applying agro-chemicals to their produce, it will help prevent or control pests and diseases infestations in order to promote the shelf life of the produce.*

Agriculture Extension Officer "C" – Wa East District

The participant was of the view that the special focus the Ministry of Agriculture has on tomato production in the district/region is that of *increasing tomato production in the area*.

On whether the Ministry has any record on tomato production in the region, the participant indicated that *the Ministry has sufficient record of tomato production in the district/region. We know which communities are leading in tomato cultivation and both in dry and wet seasons.*

When asked how the Ministry rate tomato production in the district/region, the participant stated that the rate of *tomato production in the district in terms of percentage is 55%.for wet season and 20% in approximation or even less in dry season.*

On whether all the tomatoes consumed in the study area are cultivated within the region, the participant clearly indicated that

> *No, not all the tomatoes consumed in the district/region are cultivated in the district/region. This is because we have only one raining season. During this time, majority of our farmers experience greater losses. However, in the dry season, very little is cultivated in the region and so we rely on external source*

When asked on the post-harvest handling practices used by farmers and retailers in the area the respondent indicated that *most retailers and farmers do not sort, grade, clean and disinfect their tomatoes before transporting. He also added that most of the tomatoes are harvested very ripped and further subjected to long hours of travel to market in a sunny weather conditions which can increase the rate of deterioration.*

When asked of the best post-harvest handling practices of tomatoes that can be employed by farmers and retailers in the study area to reduce post-harvest losses, the participant stated *that farmers and retailers needs to be taking through training on how to keep their farms neat and free from germs, when to harvest and how to package the produce for transport on rough roads.*

Agriculture Extension Officer "D" –Jirapa District

a. When asked of the special focus the Ministry of Agriculture has on tomato production, the participant stated that self-sufficiency in tomato production, reduction in importation, surplus for export and provision of irrigation facilities to farmers are the focus areas of the Ministry in the district.

b. On whether the Ministry has any record on tomato production in the district/region, the participant indicated that *Yes.*

c. When asked how the Ministry rate tomato production in the district/region, the participant stated that *the rate of tomato production in the district is between 35% and 45%.*

d. On whether all the tomatoes consumed in the study area are cultivated within the region, the participant clearly indicated *No, since some of the produce come from other districts or neighbouring countries such as Burkina Faso. According to the participant, the district/region alone cannot meet its own requirement*.

e. When asked on the post-harvest handling practices used by farmers and retailers in the area *the respondent explained that most tomato farms are far away from the marketing centres and transporting them from long distances to marketing centres on inappropriate vehicles and poor roads increases mechanical damages on tomatoes*.

f. When asked of the best post-harvest handling practices of tomatoes that can be employed by farmers and retailers in the study area to reduce post-harvest losses, the participant indicated *that proper packaging and transport and improvement in the quality of roads linking tomato farms to marketing centres will help in reducing losses caused by poor handling practices*

4.14 Results/Findings for Objective Two

4.14.1 Interview Responses from Agriculture Extension Officers

The objective two of the study sought to examine the causes and challenges of post-harvest losses of tomato faced by tomato handlers in the food value chain in some

selected Districts in the Upper West region of Ghana by providing the Agriculture Extension Officers' responses to the question: *What are the causes and challenges of post-harvest loss of tomatoes in some selected Districts in the Upper West Region of Ghana*

Agriculture Extension Officer "A" – Wa Municipal

a. When asked the participant whether the Ministry has data on postharvest losses of tomato in the district/region, he answered *Yes*.

b. When asked how he will rate the percentage of post-harvest loss of tomato in the district/region, the participant indicated *40%* as the percentage rate of post-harvest loss of the produce.

c. When asked of the causes of post-harvest loss of tomatoes in the district/region, he indicated the following as the causes:

   i. *Inappropriate means of transportation*
   ii. *Poor road network*
   iii. *Long distances of farms from market centres*
   iv. *Lack of readily available market for the produce*

d. On whether the Ministry trains tomato farmers on post-harvest storage technology, the participant indicated *Yes*.

e. When asked of the challenges tomato farmers and retailers face in the district, the respondent revealed that *the challenges are numerous. They ranged from skills training, infrastructure and breed of tomato used. Most farmers used locally breed of tomatoes which are full of water and seeds and easily deteriorate. Also no irrigation damps for dry season tomato cultivation*

The participant recommended the following ways to address the challenges faced by tomato handlers within the food value chain in the study area:

a. *Construction of tomato processing factories within tomato producing centres*
b. *Training tomato farmers best application of agro-chemicals*
c. *Provision of irrigation facilities for the tomato farmers*
d. *Conducting of research on traditional methods of tomato preservation*
e. *Provision of modern storage system for tomato farmers and retailers*

Improving road networks to transport produce from hinterlands to market centres

Agriculture Extension Officer "B" – Wa West District

b. When the participant was asked as to whether the Ministry has data on postharvest losses of tomato in the district/region, he answered *Yes, we have data*.
c. When asked how he will rate the percentage of post-harvest loss of tomato in the district/region, the participant indicated *40% in term of post-harvest loss of the produce because right now, if you go to the farms and market centres, they are there in abundance wasting. Imagine a farmer watching his produce perishing, he is left with no choice than to offer them cheaper to buyers. The buyer in turn offer it cheaply to customers because they are perishable but he or she doesn't have means of preserving so a lot will go waste if it is not given out cheaply.*
d. When asked of the causes of post-harvest loss of tomatoes in the district/region, he indicated that the following:
    i. Lack *of processing facilities to process tomato*
    ii. *Inadequate knowledge and/or lack of preservation equipment;*
    iii. *Diseases and pests infestations; and*

iv. *Farmers producing tomatoes at the same time or period for the same market leading to excessive glut of the produce.*

e. On whether the Ministry trains tomato farmers on post-harvest storage technology, the participant indicated *No; we do not have the resources and the finances to train and further assist them on storage technology. We are however researching to get an improve variety that can withstand the climatic conditions over here.*

f. When asked of the challenges tomato farmers and retailers face in the district, the respondent explained *that there is no readily available market for tomato produce in the major raining season, lack of processing factories, poor transport systems and lack of irrigational facilities. This makes tomato farming in the area unprofitable*

The participant gave the following as ways of addressing the challenges faced by tomato handlers within the food value chain in the study area:

i. *Execution of the Government initial plan of one village one dam and one-district one-factory initiative in the communities and districts. For instance, if there are irrigation dams in the communities, tomato farmers would not rely on only one major season for tomato cultivation. In the same vein providing tomato processing factories in these districts will also help farmers to process their harvested tomato produce into other usable forms that can be used in the near future instead of depending on only the fresh products which has less value during glut*

Agriculture Extension Officer "C" – Wa East District

a. When the participant was questioned on whether the Ministry has data on postharvest losses of tomato in the district/region, *he stated that the Ministry does not have data on the post-harvest losses of tomato in the district/region*.

b. When asked how he will rate the percentage of post-harvest loss of tomato in the district/region, the participant indicated there about *55% of post-harvest loss of the produce due to inadequate storage facilities, distance of farms to market centres and other rough handling practices by the tomato handlers.*

c. When asked of the causes of post-harvest loss of tomatoes in the district/region, he gave the following reasons:

   i. *High transportation cost;*
   ii. *Bad roads;*
   iii. *Longer distances between farms and market centres;*
   iv. *Lack of technical know-how on tomato production;*
   v. *Poor packaging technologies*

g. On whether the Ministry trains tomato farmers on post-harvest storage technology in the district/region, the participant stated *Yes, farmers have been trained on post-harvest technology.*

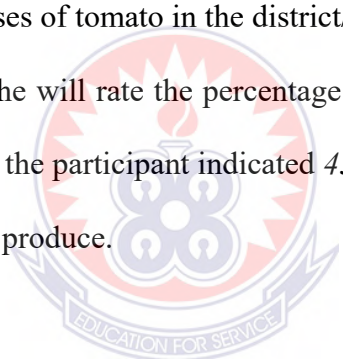
When asked of the challenges tomato farmers and retailers face in the district, the respondent indicated *that the major challenge has to do with the soil type and the type of seedling that does well with the nature of the soil. The local breed has so much water content and seeds but does very well in the area. However its keeping value is less as compared with Burkina breed of tomatoes.*

The participant acknowledged the following as ways of addressing the challenges faced by tomato handlers within the food value chain in the study area:

i. *Establishment of processing facilities to process tomatoes into paste will promote the shelf life of the produce.*
ii. *Encouraging farmers to cultivate tomato varieties that can stay longer period of life.*
iii. *Encouraging the traditional methods of handling and treating tomatoes will help enhance the shelf life of the produce, even though no extensive research has been done on them.*

Agriculture Extension Officer "D" – Jirapa District

b. When asked the participant whether the Ministry in the district/region has data on postharvest losses of tomato in the district/region, he answered *Yes*.
c. When asked how he will rate the percentage of post-harvest loss of tomato in the district/region, the participant indicated *45%* as the percentage rate of post-harvest loss of the produce.



d. When asked of the causes of post-harvest loss of tomatoes in the district/region, he gave the following factors:
    - *Lack of proper storage system*
    - *Poor road network*
    - *Long distance between farms and market centres*
    - *Inadequate knowledge in the application or utilization of chemicals for pests and disease control or prevention.*
e. On whether the Ministry trains tomato farmers on post-harvest storage technology, the participant indicated *Yes*.

A significant number of the farmers and retailers have undergone some training on post-harvest handling of farm produce.

When asked of the challenges tomato farmers and retailers face in the district, the respondent revealed that *farmers are faced with high cost of production and low prices of produce, lack of factories to reduce waste, low patronage during major raining seasons and lack of irrigational facilities to practice dry season cultivation which is associated with high demand for the produce.*

The participant acknowledged the following as ways of addressing the challenges faced by tomato handlers within the food value chain in the study area:

a. *Building of a factory within the tomato producing centres (that is areas where there is abundance of tomatoes) for processing; and*
b. *Provision of irrigation facilities for the tomato farmers.*

4.15 Results/Findings for Objective three

4.15.1 Interview Responses from Agriculture Extension Officers

The objective three of the study sought to determine the treatment methods that can be used by tomato handlers to minimize post-harvest losses faced by tomato farmers and retailers in the Upper West region of Ghana by providing the Agriculture Extension Officers' responses to the question: *What are the treatment methods that can be used by tomato handlers to minimize post-harvest losses faced by tomato farmers and retailers in some selected Districts in the Upper West region of Ghana?*

Agriculture Extension Officer "A"- Wa Municipal

On the treatment methods that can help tomato farmers and retailers to significantly reduce Post-harvest losses, the participants made the following observations:

...establishment of tomato processing factories in district centres, chilling, freezing and employing various drying methods of tomato product so that during the lean season tomatoes can be used by farmers or consumers in the district or the region. The participant further revealed that tomato farmers and retailers do no employ these treatment methods for lack of skills, knowledge and facilities

Agriculture Extension Officer "B" – Wa West District

On the treatment methods that can help tomato farmers and retailers to significantly reduce Post-harvest losses, the participants made the following observations:

> *Post-harvest losses normally start from the field, and if diseases affect plants, post-harvest losses are bound to occur. Therefore, it is important to train farmers on how to apply agro chemicals in order to minimize post-harvest losses and preserve the shelf life of the produce. Marketing of the produce is another way of helping to reduce glut because if farmers and retailers gain more insight into appropriate marketing strategies, the produce will not stay longer with them to experience post-harvest loss. When farmers are also made aware of when to harvest the produce, transport and sell them, incidence of tomato wastage will be reduced.*

Agriculture Extension Officer "C" – Wa East District

On the treatment methods that can help tomato farmers and retailers to significantly reduce Post-harvest losses, the participants made the following observations:

> *I recommend farmers and retailers to explore various drying techniques and use them to preserve their produce.Government should also assist the various regions with processing plant. Individuals can also acquire deep freezers for themselves to preserve their produce.*

Agriculture Extension Officer "D" – Jirapa District

> On the treatment methods that can help tomato farmers and retailers to significantly reduce Post-harvest losses, the participants advocated for the *provision for cold storage facilities as freezers and refrigerators chilling and freezing tomatoes, establishment of tomato processing factories in district centres, and improvement in drying technology.*
>
> He added that *ordinarily washing the produce in clean water and rinsing with common salt solution serves as a treatment and can reduce spoilage rate.*

4.16 Summary

The chapter four of this study sought to analyse the quantitative and qualitative data that were obtained from the participants of the study. The questionnaire items and interview questions bothered on handling practices, causes, challenges and post-harvest treatment methods of tomato in some selected districts within the Upper West region of Ghana.

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

This chapter presents the summary, conclusion and recommendations based on the objectives set of this study.

5.1 Summary

The chapter one of this study presented general information on the concept of post-harvest handling practices, causes of post-harvest loss of tomatoes, challenges and treatment methods used by tomato farmers and retailers in the upper west region of Ghana. This chapter likewise presented the problems that necessitated the conduct of this study. It outlined the objectives and the significance of the study. Furthermore, the terms used in this paper were clearly defined. The chapter two of the study reviewed the extant literature on these sub-topics: concepts of post–harvest loss of food, variety of tomato, causes of post–harvest loss of fresh fruits and vegetables (Tomatoes), marketing of tomato, treatment methods for tomatoes to reduce post–harvest loss, challenges facing tomato farmers and retailers, concept of value chain in tomato production and the conceptual framework of the study.

The chapter three (3) deliberated the research design, research method, population, sampling, research instrumentation, data collection technique, limitation, delimitation, data analysis procedure, validation of instruments and ethical consideration.

The chapter four (4) of this study analysed and discussed the findings of the study based on the research objectives.

The chapter five summarized, concluded and made recommendations of this study based on the set objectives.

5.1.2 Summary of the Main Findings

Proper post-harvest handling skills are required by all tomato handlers (farmers and retailers) to enhance the shelf life of the produce in order to maximize both production and sales benefits. Concerning the fallouts from the data, which was obtained from the field, the results of this study were as follow:

i. The study established that tomatoes are harvested in the morning in matured (ripped) reddish form by farmers and transported to retailers.

ii. Tomato farmers do not sort, grade and pre-cooled their tomato produce after harvest before packaging for transportation. Retailers however practice sorting and grading after buying from farmers but have no knowledge of pre-cooling.

iii. The study revealed that both farmers and retailers do not clean and disinfect their tomato produce to reduce microbial contamination.

iv. The study found that poor packaging and inappropriate transport systems used by tomato handlers subject the produce to high degree of perishability.

v. The study found that the significant causes of post-harvest loss of tomatoes includes loss through mechanical damage, limited available market, Inappropriate transport and bad nature of the roads, diseases and pests infestations, low quality of locally produced tomatoes, long distances of farming communities to marketing centres and so many farmers producing tomatoes at the same time or period for the same market leading to excessive glut of the produce.

vi. The study found that the challenges farmers face were lack of effective irrigation facilities for tomato farmers which is associated with insufficient production of tomatoes during lean seasons, lack of storage facilities, lack of technical support, the use of inappropriate packaging materials for transporting

tomatoes, inappropriate means of transporting produce, problem of reliable market for tomato produce, high cost of production of tomatoes and low price of produce during peak season.

vii. The study established that sun drying of tomatoes was the only tomato treatment method commonly used by tomato farmers and retailers in the study area.

viii. The establishment of tomato processing factories to process fresh tomatoes into other useable forms, the use of edible coating and chemical (sodium hypo chloride) to preserve tomatoes and other drying techniques were identified as appropriate treatment methods that can help to enhance the quality and shelf life of the produce but not practiced in the study areas as a result of lack of knowledge and unavailability of facilities to practice them.

5.2 Conclusion

The study revealed that tomatoes are harvested early in the morning in matured reddish state for transported. Longer distance of travelling to marketing centres render the produce to perish faster.

Tomatoes are not sorted, graded and pre-cooled to remove overly ripped, under ripped, small and big one. No pre-cooling is also done to remove heat and warmth from tomatoes which can render it perish.

Tomatoes are inappropriately packaged and transported in inappropriate vehicles which increases mechanical damages on the produce

The longer hours of travelling from tomatoes farms to marketing centres with an already ripped tomatoes in undulating roads increases spoilage rate before tomatoes finally get to the consumer.

The study discovered that. mechanical damage, limited available market, Inappropriate transport and bad nature of the roads, diseases and pests infestations, low quality of locally produced tomatoes, long distances of farming communities to marketing centres and so many farmers producing tomatoes at the same time or period for the same market leading to excessive glut of the produce as the cause of post-harvest loss of tomatoes in the selected districts in the Upper West Region.

The study revealed that lack of effective irrigation facilities for tomato farmers, lack of storage facilities, lack of technical support, the use of inappropriate packaging materials for transporting tomatoes, inappropriate means of transporting produce, problem of reliable market for tomato produce, high cost of production of tomatoes and low price of produce during peak season as challenges confronting tomato farmers and retailers.

The study also revealed that sun drying of tomatoes was one of the common treatment method of tomato by both farmers and retailers in the study area.

The study also identified other treatments methods available but not commonly practiced in the study area to include application of heat by canning, adoption of edible coating and chemical (sodium hypo chloride), irradiation and other drying techniques which are suitable treatment methods that can help tomato farmers and retailers enhance the quality and shelf life of the produce but which farmers and retailers in the study area are not conversant with.

5.3 Recommendations

The post-harvest practices of handling and treatment of tomatoes is a herculean task, and therefore, demand stakeholder engagement and concerted efforts at the level of production, commercialization and consumption of the produce in order to address the

food value chain bottlenecks such as gluts and cost. This study makes the following recommendations in order to address the handling practices, causes of post-harvest loss of the produce and the challenges faced by the produce handlers (farmers and retailers):

- The Ministry of Food and Agriculture in collaboration with the Municipal and District Extension Officers should organize training workshops to equip farmers and retailers with the desired skills in the appropriate handling practices of tomatoes to reduce post-harvest losses.
- The Municipal and Districts Assembles should create market space solely for tomatoes and design appropriate market structures conducive and convenient for the sale of tomatoes by tomato farmers, retailers and consumers for easy access and market of produce.
- Non- Governmental Organizations which have interest in Agriculture should established tomato processing factories in these tomato growing districts to assist them reduce excessive losses by processing fresh tomatoes into puree/paste and other useable forms during glut to enhance sales and maximization of profit.
- The Government in a bit to promote Agriculture, should provide loans to hardworking persons who have the strong edge to go into tomato farming and retailing. This will equip them with the needed capital to farm and take proper care of their tomato produce for quality yields.
- Irrigation dams and equipment should also be constructed and supplied by the Government to tomato farming communities to engage in dry season tomato farming since there is only one major raining season in the study area, hence

majority of the farmers rely on that causing glut and low sales during major seasons.

- Agriculture Extension Officers should come out with a recommended variety of tomato seeds suitable for the study area. This will enable tomato farmers, retailers and consumers enjoy quality yet affordable tomatoes and also tomato farmers and retailers will maximize profit from the sale of their produce.
- Government and other relevant stakeholders should as a matter of urgency construct good roads to link tomato farming communities to marketing centres to reduce produce glut and wastages in the farming communities.
- Government and other relevant stakeholders should as a matter of urgency should endeavor to provide proper storage facilities, chemicals for checking disease and pests infestations and institution of farming subsidies to help farmers and retailers reduce cost and maximized profit.
- Tomato farmers and retailers in the various district should be linked to boarding and day schools in their respective districts as suppliers of tomatoes for the school feeding program by the various district assembles.

5.3.1 Recommendation for Further Studies

Further studies on this subject can be done by undertaking an intervention such as exploring various techniques of preserving tomatoes to extend shelf life without compromising quality.

REFERENCES

Abimbola, O. A. (2014). Post-harvest losses and welfare of tomato farmers in Ogbomosho, Osun state Nigeria. *Journal of Stored Products and Postharvest Research, 5*(2), 8-13.

Addo, J. K., Osei, M. K., Mochiah, M. B., Bonsu, K. O., Choi, H. S., & Kim, J. G. (2015). Assessment of farmer level postharvest losses along the tomato value chain in three agro-ecological zones of Ghana. *International Journal*, *2*(9), 2311-2476.

Adekunle, A. A., Omoare, A. M., & Oyediran, W. O. (2014). Rural women's skill acquisition in the processing of locust bean in Ipokia Local Government Area of Ogun State, Nigeria. *World Academy of Science, Engineering and Technology (WASET), 85,* 531-536. url: http://waset.org/Publications?p=85

Adeoye, I. B., Odeleye, O. M. O., Babalola, S. O., & Afolayan, S. O. (2009). Economic analysis of tomato losses in Ibadan metropolis, Oyo State, Nigeria. *African Journal of Basic and Applied Sciences*, *1*(56), 87-92.

Adu-Dapaah, H. K., & Oppong-Konadu, E. Y. (2002). Tomato production in four major tomato-growing districts in Ghana: Farming practices and production constraints. *Ghana Journal of Agricultural Science*, *35*(1), 11-22.

Agana, G. L. (2018). Organic agriculture, food safety and supply in Northern Ghana-CAOF's Strategy. In *Ecological and Organic Agriculture Strategies for Viable Continental and National Development in the Context of the African Union's Agenda 2063. Scientific Track Proceedings of the 4th African Organic Conference. November 5-8, 2018. Saly Portudal, Senegal* (93-98).

Agboola, S. D. (1980). *The Role of the Nigerian Stored Products Research Institute in Nigeria's March Towards Self Sufficiency in Food*. Federal Ministry of Science and Technology, Nigerian Stored Products Research Institute.

Agyedu, M., Donkor, J., & Obeng, B. (1999). *Research methods*. Kumasi: UST Press Limited.

Aidoo, R., Danfoku, R. A., & Mensah, J. O. (2014). Determinants of postharvest losses in tomato production in the Offinso North district of Ghana. *Journal of Development and Agricultural Economics*, *6*(8), 338-344.

Ajagbe, B. O., Oyediran, W. O., Omoare, A. M., & Sofowora, O. O. (2014). Assessment of post-harvest practices among tomato (Solanum Lycopersicum) farmers/processors in Abeokuta North local government area, Ogun State, Nigeria. *International Journal of Education and Research*, *2*(3), 1-12.

Akbudak, B., Akbudak, N., Seniz, V., & Eris, A. (2012). Effect of pre-harvest harpin and modified atmosphere packaging on quality of cherry tomato cultivars "Alona" and "Cluster". *British Food Journal*, *45*, 67-78.

Akhtar, A., Abbasi, N. A., & Hussain, A. Z. H. A. R. (2010). Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. *Pakistan Journal Bot*, *42*(1), 181-188.

Alam, M. S., Sultana, N., Ahmad, S., Hossain, M. M., & Islam, A. K. M. A. (2010). Performance of heat tolerant tomato hybrid lines under hot, humid conditions. *Bangladesh Journal of Agricultural Research*, *35*(3), 367-373.

Anaba, G. (2018). *Assessment of Postharvest Losses along the Fresh Tomato Value Chain in the Upper East Region of Ghana* (Doctoral dissertation, University of Ghana).

Anang, B. T., Zulkarnain, Z. A., & Yusif, S. (2013). Production constraints and measures to enhance the competitiveness of the tomato industry in Wenchi Municipal District of Ghana. *Journal of Experimental Agriculture International*, 824-838.

Andah, A. (2000). *Technological transitions: technical upgrading of indigenous food technologies in Africa*. United Nations, Economic Commission for Africa, Food Security and Sustainable Development Division.

Annku, E. (2014). *Technology-enhanced teaching and learning: a case of the faculty of art in Kwame Nkrumah University of science and technology.* MPhil. Dissertation of Department of General Art Studies, KNUST.

Arab, L., & Steck, S. (2000). Lycopene and cardiovascular disease. *AJCN, 71*(6), 91S-95S.

Arah, I. K., Ahorbo, G. K., Anku, E. K., Kumah, E. K., & Amaglo, H. (2016). Postharvest handling practices and treatment methods for tomato handlers in developing countries: A mini review. *Advances in Agriculture*, *20,* 1-6.

Arah, I. K., Amaglo, H., Kumah, E. K., & Ofori, H. (2015). Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: A mini review. *International Journal of Agronomy*, *23-45.*

Arah, I. K. (2014). *An Overview of Post-harvest Challenges Facing Tomato Production in Africa*. African Studies Association of Australasia and the Pacific (AFSAAP) 37th Annual Conference – Dunedin – New Zealand – 25-26 November 2014 Conference Proceedings (Published January 2015) 21.

Arjenaki, O. O., Moghaddam, P. A., & Motlagh, A. M. (2013). Online Tomato Sorting Based on Shape, Maturity, Size and Surface Defects Using Machine Vision. *Turkish Journal of Agriculture and Forestry, 37*(1).

Artés, F., Gómez, P., Aguayo, E., Escalona, V., & Artés-Hernández, F. (2009). Sustainable sanitation techniques for keeping quality and safety of fresh-cut plant commodities. *Postharvest Biology and Technology*, *51*(3), 287-296.

Artes, F., Gomez, P., Anguayo, E., Escalana, V., & Artes–Hernandez, F. (2009). Sustainable sanitation techniques for keeping quality and safety of fresh – cut post – harvest Biol. *Technology, 51*, 287–296.

Artés-Calero, F., Aguayo, E., Gómez, P., & Hernandez, F. A. (2009). Distribución Alimentación> Poscosecha> Acondicionamiento de productos en fresco.

Aryeetey, E. (2006). ISSER-Merchant Bank Development Seminar Series. Ghanaweb. (Online) http://www.ghanaweb.com/GhanaHomePage/election2008/artikel.php?ID=101256.

Ashby, B. H. (2000). *Protecting perishable foods during transport by truck.* Agriculture handbook-United States. Dept. of Agriculture (USA).

Aulakh, J., Regmi, A., Fulton, J., & Alexander, C. (2013). Food losses: Developing a consistent global estimation framework. In *Agricultural and applied economics association annual meeting, August* (4-6).

Awunyo-Vitor, D., Wongnaa, C. A., & Aidoo, R. (2016). Resource use efficiency among maize farmers in Ghana. *Agriculture & Food Security*, *5*(1), 28.

Ayandiji, A., Adeniyi, O. D., & Omidiji, D. (2011). Determinant post-harvest losses among tomato farmers in Imeko-Afon local government area of Ogun State, Nigeria. *Global Journal of Science Frontier Research*, *11*(5), 23-27.

Aysel, E., Derya, K. Y., Yildiray, I., Nurcan, A. G., Arzu, Y., & Fahrettin, G. (2019). Strategies to Reduce Postharvest Losses for Fruits and Vegetables. *An International Journal of Scientific and Technology Research, 5*(3), 12-45.

Babalola, D. A., Makinde, Y. O., Omonona, B. T., & Oyekanmi, M. O. (2010). Determinants of post-harvest losses in tomato production: A case study of Imeko-Afon local government area of Ogun state. *Acta Ssatech*, *3*(2), 14-18.

Babatola, L. A., Oji, D. A., & Lawal, O. I. (2008). Effect of Storage condition on Tonmato (Lycopersiconesculentum Mill.) Quality and Shelf Life. Journal of biological sciences, *5*, 11-21.

Babitha, K. C., Ninganur, B. T., Chetti, M. B., Jirali, D. I., & Harlapur, S. I. (2010). Effect of post-harvest treatments and storage conditions on physio-chemical parameters in extending shelf life in tomato. *Plant Archives*, *10*(1), 37-47.

Bachmann, J., & Earles, R. (2000). *Postharvest handling of fruits and vegetables,* 1-19. ATTRA.

Barbosa-Cánovas, G. V. (2003). *Handling and preservation of fruits and vegetables by combined methods for rural areas: technical manual* (No. 149). Food & Agriculture Org.

Barton Essel, H., (2011). *Knowledge Management of Postgraduate Thesis in KNUST.* PhD Dissertation of Department of General Art Studies, KNUST.

Batu, A., & Thompson, A. K. (1998). Effects of controlled atmosphere storage on the extension of postharvest qualities and storage life of tomatoes. In *Control Applications in Post-Harvest and Processing Technology 1995*, 311-316. Pergamon.

Beckles, D. M. (2012). Factors affecting the postharvest soluble solids and sugar content of tomato (Solanum lycopersicum L.) fruit. *Postharvest Biology and Technology*, *63*(1), 129-140.

Burns, N., & Grove, S. K. (2011). *Undertaking nursing research: Building an evidence-based practice*. Amsterdam: Elsevier.

Buyukbay, E. O., Uzunoz, M., & Bal, H. S. G. (2011). Post-harvest losses in tomato and fresh bean production in Tokat province of Turkey. *Scientific Research and Essays*, *6*(7), 1656-1666.

Buyukbay, E. O., Uzunoz, M., & Bal, H. S. G. (2010). Postharvest Losses in Tomato and Fresh Bean production in Tokat Province of Turkey. *Scintific Research and Essays, 6*(7), 1656-1666.

Buzby, J. C., & Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy, 37*(5), 561-570.

Campbell, P. (2011). *Assessing the Knowledge, Attitudes and Practices of Street Food Vendors in the city of Johannesburg regarding Food Hygiene and Safety.* Unpublished mini-thesis, University of Western Cape.

Cantwell, M., Nie, X., & Hong, G. (2009). Impact of storage conditions on grape tomato quality. In *6th ISHS postharvest symposium, Antalya, Turkey*.

Charles, A. O. (2009). Reducing Post harvest Losses of Horticultural Commodities in Nigeria through Improved Packaging. *International Union of Food and Science and Institute of Food Technologists*.

Chaves, A. L. R., Eiras, M., Colariccio, A., Moreira, S. R., & Chagas, C. M. (2001). Detection of the Groundnut ringspot tospovirus in lettuce and tomato plants in Sao Paulo State. *Summa Phytopathologica*, *27*(1), 50-53.

Chun-Ta, W. (2010). *An overview of postharvest biology and technology of fruits and vegetables. Workshop on technology on reducing postharvest losses and maintaining quality of fruits and vegetables*. Taiwan: AARDO.

Cliff, M., Lok, S., Changwen, Lu, Toivonen, P. M. A. (2009). Effect of 1-methylcyclopropene on the sensory, visual, and analytical quality of greenhouse tomatoes. *Postharvest Biological Tecnology, 53*, 11- 15.

Clottey, V. A., Karbo, N., & Gyasi, K. O. (2009). The tomato industry in northern Ghana: Production constraints and strategies to improve competitiveness. *African Journal of Food, Agriculture, Nutrition and Development*, *9*(6), 56-67.

Creswell, J., & Plano Clark, V. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.).Thousand Oaks, CA: Sage Publications, Inc.

De Castro, L. R., Vigneault, C., & Charles, M. T. (2005). *Effect of cooling delay and cold-chain breakage on'Santa Clara'tomato* (No. RESEARCH).

De Wild, H. P., Otma, E. C., & Peppelenbos, H. W. (2003). Carbon dioxide action on ethylene biosynthesis of preclimacteric and climacteric pear fruit. *Journal of Experimental Botany*, *54*(387), 1537-1544.

Deribe, H., Beyene, B., & Beyene, B. (2016). Review on pre and post-harvest management on quality tomato (Lycopersicon esculentum Mill.) production. *Food Science and Quality Management*, *54*, 72-79.

Devkota, A. R., Dhakal, D. D., Gautam, D. M., & Dutta, J. P. (2014). Assessment of fruit and vegetable losses at major wholesale markets in Nepal. *International Journal of Applied Sciences & Biotechnology, 2*(4), 559-562. DOI: 10.3126/ijasbt.v2i4.11551

Egyir, I. S., Sarpong, D. B., & Obeng-Ofori, D. (2008). Harvest and Post-harvest Baseline Study. *Policy, Planning, Monitoring and Evaluation Directorate Ministry of Food and Agriculture, Ghana*.

Elik, A., Yanik, D. K., Istanbullu, Y., Guzelsoy, N. A., Yavuz, A., & Gogus, F. (2019). Strategies to reduce post-harvest losses for fruits and vegetables. *Strategies*, *5*(3), 45-67.

Ellis, W. O., Olympio, N. S., Mensah, E. P., Adu-Amankwa, A., & Tetteh, Y. (1998). Postharvest problems of tomato production in Ghana - Field studies of some selected major growing areas in Ghana. *Journal of the Ghana science association, 1*(1), 55-59. ISSN: 0855-3823.

Emana, B., Afari-Sefa, V., Nenguwo, N., Ayana, A., Kebede, D., & Mohammed, H. (2017). Characterization of pre-and postharvest losses of tomato supply chain in Ethiopia. *Agriculture & Food Security*, *6*(1), 3.

Esguerra, E. B., Rolle, R., & Rahman, M. A. (2018). Post-harvest management of mango for quality and safety assurance. *Guidance for horticultural supply chain stakeholders: Food and Agriculture Organization of the United Nations, Rome*.

FAO & INPhO (1998). *Fruit and vegetable processing. Methods for tomato preservation.* Infonet-biovision.

FAO (1988). FAO/Unesco Soil Map of the World, Revised Legend, with corrections and updates. World Soil Resources Report 60. FAO, Rome. Reprinted with updates as Technical Paper 20. ISRIC, Wageningen, 1997.

FAO (2008). *Basic Harvest and Post-Harvest Handling Considerations for Fresh Fruits and Vegetables handling and Preservation*. Rome: Italy.

FAO, U. (2014). FAO stat. *Retrieved Feb*, *2014*.

FAOSTAT, (2014). Global Tomato Production in 2013, FAO, Rome, Italy.

Food and Agricultural Organization of the United Nations (2011). *Global Food Losses and Food Waste-Extent, Causes and Prevention.*

Food and Agriculture Organisation of the United Nations (FAO) (2010). Global hunger declining, but still unacceptably high. FAO, Economic and Social Development Department.

Food and Agriculture Organization of the United Nations (FAO) (2011). *Global food losses and food waste*; extent, causes and prevention.

Gebru, H., & Derbew, B. (2015*). Extend, Causes and Reduction Strategies of Postharvest Losses of Fresh Fruits and Vegetables-A Review*. Ethiopia: Del Press.

Gerasopoulos, D., & Drogoudi, P. D. (2005). Summer-pruning and pre-harvest calcium chloride sprays affect storability and low temperature breakdown incidence in kiwifruit. *Postharvest Biology and Technology*, *36*(3), 303-308.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of international political economy*, *12*(1), 78-104.

Getinet, H., Seyoum, T., & Woldetsadik, K. (2008). The effect of cultivar, maturity stage and storage environment on quality of tomatoes. *Journal of Food Engineering, 87*(4), 467-478.

Getinet, H., Workneh, T. S., & Woldetsadik, K. (2011). Effect of Maturity Stages, Variety and Storage Environment on Sugar Content of Tomato Stored in Multiple Pads Evaporative Cooler. *African Journal of Biotechnology, 10*(80).

Gibbon, P. (2008). Governance, Entry Barriers, Upgrading: A Re-Interpretation of Some GVC Concepts from the Experience of African Clothing Exports. *Competition and Change, 12*(1), 29-48.

Gould, W. A. (1992). *Tomato production, processing and technology*. Baltimore: CTI Publisher.

Gustavo, B. C. V., Juan, F. M. J., Stella, M., Maria, S. T., Aurelio, L. M., & Jorge, W. C. (2003). Handling and preservation of fruits and vegetables by combined methods for rural areas. *Technical Manual FAO Agricultural Services Bulletin*, *149*.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste*.

Hailu, G., & Derbew, B. (2015). Extent, causes and reduction strategies of postharvest losses of fresh fruits and vegetables – A review. *Journal of Biology, Agriculture and Healthcare*, *5*(5), 49-64.

Hale, J. (2011). The 3 basic types of descriptive research methods. *Psych Central, 5*, 99-105.

Hsu, C., & Sandford, B. A. (2010). *Instrumentation*. London: Sage Publication. Retrieved April, 7, 2013.

Hurst, W. C. (2010). *Harvest, Handling and Sanitation Commercial Tomato Production.* Chicago: Handy Press.

Idah, P. A., Ajisegiri, E. S. A., & Yisa, M. G. (2007). Fruits and vegetables handling and transportation in Nigeria. *AU Journal of Technology*, *10*(3), 175-183.

Ilyas, S. M. (2010). Best practices for efficient postharvest management of fruits and vegetables for higher value addition and profitability. In *Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables: Proceedings of 2010 AARDO Workshop*.

Issahaku, H. (2012). An analysis of the constraints in the tomato value chain. *International Journal of Business and Management Tomorrow*, *2*(10), 1-8.

Joas, J., & Lechaudel, M. (2008). A Comprehensive Integrated Approach for more Effective Control of Tropical Fruits Quality. *Stewart Postharvest Review, 4*(2).

Joint, F. A. O., & World Health Organization, (1995). *Application of risk analysis to food standards issues: report of the Joint FAO* (No. WHO/FNU/FOS/95.3. Unpublished). World Health Organization.

Kader, A. A., & Watkins, C. B. (2000). Modified atmosphere packaging toward 2000 and beyond. *Hort Technology, 10*(3), 483–486.

Kader, A. A. (1984). Effects of postharvest handling procedures on tomato quality. In *Symposium on Tomato Production on Arid Land 190,* 209-222.

Kader, A. A. (2013). Impact of nut postharvest handling, de-shelling, drying and storage on quality. *In Improving the safety and quality of nuts*, 22-34. Melbourne: Woodhead Publishing.

Kader, A. A., & Rolle, R. S. (2004). *The role of post-harvest management in assuring the quality and safety of horticultural produce,* 152. Food & Agriculture Organization.

Kader, A. A. (2005). Increasing Food availability by reducing postharvest losses of fresh produce. *Acta Horticulture, 682,* 2169-2176.

Kaplinsky, R. (2000). Globalisation and unequalisation: What can be learned from value chain analysis? *Journal of Development Studies*, *37*(2), 117-146.

Kaplinsky, R., & Morris, M. (2001). *A handbook for value chain research*. Brighton: University of Sussex, Institute of Development Studies.

Keno, K. (2011). Center for Regional and Local Development Studies Challenges and Opportunities of Horticulture Industry and Its Contribution to the Ethiopian Export Diversification: The Case of Sebeta Area Farms, Finfinne Surrounding

Special Zone. An MSc Thesis Presented to the School of Graduate Studies of Addis Ababa University. 1-50p.

Key, J. P. (1997). Descriptive research. Canada: Pearl Press.

Kiaya, V. (2014). Post-harvest losses and strategies to reduce them. *Technical Paper on Postharvest Losses, Action Contre la Faim (ACF)*, *25*, 151-162.

Kitinoja, L. (2004). Small-Scale Marketing Strategies Manual. *UC PTRIC Hort Series, 21*, 1-8.

Kitinoja, L., & Gorny, J. R. (2010). *Postharvest technology for small-scale produce marketers: economic opportunities, quality and food safety. University of California Postharvest Horticulture Series No. 21*, 52-69.

Knapp, S. (2002). Tobacco to tomatoes: A phylogenetic perspective on fruit diversity in the Solanaceae. *Journal of Experimental Botany*, *53*(377), 2001-2022.

Kodjogbe, G., Pali, C., Agyemang, N. F., Asamoah, M., Kouame, C., Gnonlonfin, B., Hell, K., & Coulibaly, O. (2010). A commodity system analysis to reduce postharvest losses of vegetable. *AVRDC, 20*, 120-130.

Kohls, R. L., & Uhl, J. N. (1985). Standardization and grading. *Marketing of Agricultural Products, Collier Macmillan,* 350-369.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. Birmingham: New Age International.

Kumar, S. R., Kiruba, R., Balamurugan, S., Cardoso, H. G., Birgit, A. S., Zakwan, A., & Sathishkumar, R. (2014). Carrot antifreeze protein enhances chilling tolerance in transgenic tomato. *Acta physiologiae Plantarum*, *36*(1), 21-27.

Lara, I., Garca, P., & Vendrell, M. (2004). Modifications in cell wall composition after cold storage of calcium-treated strawberry (Fragaria× ananassa Duch.) fruit. *Postharvest Biology and Technology*, *34*(3), 331-339.

Lee, Y., Kim, J., & Chung, D. S. (2008). The effect of 1-MCP (1-methylcyclopropene) treatment methods on the ripening process of tomato fruit during postharvest storage. *Horticulture Environment and Biotechnology*, *49*(3), 175-181.

Lurie, S. (1998). Post – harvest heat treat meats post – harvest Biol. *Technology, 14*, 257 – 269.

Mahajan, P. V., Caleb, O. J., Singh, Z., Watkins, C. B., & Geyer, M. (2014). *Postharvest treatments of fresh produce. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *372*(217), 201-303.

Malhotra, N. K., & Birks, D. F. (2007). *Marketing research: An applied approach*. United Kingdom: Pearson Education.

Manzoor, N., Muhammad, I., Aid, H., & Khuram, N. S. (2006). *Postharvest Economic Losses of Tomato Crop Grown in Pesha War Valley*.

Ministry of Food and Agriculture (MOFA) Ghana (2008). *Production guide for tomato.* MOFA information Resource Centre, Ghana.

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing Research, 40*, 120–123.

Mostofi, Y., Toivonen, P. M., Lessani, H., Babalar, M., & Lu, C. (2003). Effects of 1-methylcyclopropene on ripening of greenhouse tomatoes at three storage temperatures. *Postharvest Biology and Technology*, *27*(3), 285-292.

Muhammad, R. H., Bamisheyi, E., & Olayemi, E. F. (2011). The effect of stage of ripening on the shelf life of tomatoes (Lycopersi conesculentum) stored in the evaporative cooling system (ECS). *Journal of Dairying Foods & Home Sciences*, *30*(4), 299-301.

Muhammad, R. H., Hionu, G. C., & Olayemi, F. F. (2012). Assessment of the post-harvest knowledge of fruits and vegetable farmers in Garun Mallam L.G.A. of Kano, Nigeria. *International Journal of Development and Sustainability, 1*(2), 510–515.

Mujib, U. R., Naushad, K., & Inayatullah, J. (2007). Post-harvest losses of tomato crop. *Sarhad Journal of Agriculture*, *23*(4), 1279.

Mujibur, R., Naushad, K., & Inayatullah, J. (2007). *Postharvest Losses in Tomato Crop: A case of Peshawar Valley*. *Organic vegetables cultivation in Malaysia: Malaysia Agricultural Research and Development Institute* (MARD). Malaysia: Kuala Lumpur.

National Institutes of Health. Office of Behavioral and Social Sciences Research. (2001). *Qualitative research methods in health research: Opportunities and considerations in application and review. Retrieved from http://obssr. od. nih. gov/publications/qualitative/PDF*.

Nicola, S., Tibaldi, G., Fontana, E., Crops, A. V., & Plants, A. (2009). Tomato production systems and their application to the tropics. *Proc. IS on tomato in the tropics. Acta Horticulturae*, *821*, 27-33.

Nirupama, P., Gol, N. B., & Rao, T. R. (2010). Effect of post-harvest treatments on physicochemical characteristics and shelf life of tomato (Lycopersicon esculentum Mill.) fruits during storage. *American-Eurasian Journal of Agricultural & Environmental Sciences*, *9*(5), 470-479.

Nnenna, A. O. (2011). Rural Farmers' Problems in Accessing Agricultural Information: A Case Study of Nsukka Local Government Area of Enugu State, Nigeria. Nnamdi Azikiwe Library University of Nigeria, Nsukka. Library Philosophy and Practice. ISSN 1522-0222 http://unllib.unl.edu/LPP/

Nyamah, E. Y. (2020). Perception and adoption determinants of pre and post-harvest technologies: tomato value chain perspective. *International Journal of Postharvest Technology and Innovation*, *7*(2), 137-155.

Ofori, E. (2017). *Assessment of Students' Attitudes and Perceptions toward Information and Communication Technologies: A Case of Sunyani Technical University*. MPhil. Thesis. KNUST. Kumasi: Department of General Art Studies.

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I., & Daura, A. M. (2010). Assessment of post-harvest challenges of small scale farm holders of tomotoes, bell and hot pepper in some local government areas of Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *3*(2), 39-42.

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I., & Daura, A. M. (2010). Assessment of post-harvest challenges of small scale farm holders of tomotoes, bell and hot pepper in some local government areas of Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *3*(2), 39-42.

Orzolek, M. D., Bogash, M. S., Harsh, M. R., Lynn, F., Kime, L. F., Jayson, K., & Harper, J. K. (2006). Tomato Production. *Agricultural Alternatives Publication, 291*, 2-3.

Owusu-Sekyere, J. D., & Andoh, J. (2011). Assessment of deficit Irrigation on the growth and yield of some vegetable crops. *Department of Agricultural Engineering, University of Cape Coast, Ghana*.

Oyekanmi, M. O. (2007). *Determinants of postharvest losses in tomato production: a case study of Imeko-Afon Local Government Area of Ogun State*. Unpublished B.Sc. thesis, Department of Agriculture, Babcock University.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 3065-3081.

Parnell, T., Suslow, T., & Harris, L. (2004). *Tomatoes: Safe methods to store, preserve, and enjoy*. Cambridge: UCANR Publications.

Paul, R. (1999). Effect of temperature and relative humidity on fresh commodity quality. *Postharvest Biology and Technology*, *15*(3), 263-277.

Peralta, I., Knapp, S., & Spooner, D. (2007). The taxonomy of tomatoes: a revision of wild tomatoes (Solanum L. section Lycopersicon (Mill.) Wettst.) and their outgroup relatives (Solanum sections Juglandifolium (Rydb.) Child and Lycopersicoides (Child) Peralta). *Systematic Botany Monographs*, *84*, 1-186.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: The Free Press.

Raikes, P., Jensen, M. F., & Ponte, S. (2000). Global commodity chain analysis and the French Filière approach: comparison and critique. *Economical Society, 29*(3), 390–417.

Raison, J. K., & Lyons, J. M. (1986). Chilling injury: A plea for uniform terminology. *Plant Cell Environ, 9*, 685-686.

Risse, L. A., Miller, W. R., & McDonald, R. E. (1984). Effects of film wrapping on mature green tomatoes before and after ethylene treatment. In *Proc. Fla. State Hort. Soc*., *97*, 112-114.

Robertson, L. D., & Labate, J. A. (2007). Genetic resources of tomato (Lycopersicon esculentum Mill.) and wild relatives. *Genetic improvement of Solanaceous crops. Tomato*, *2*, 25-75.

Robinson, E. J., & Kolavalli, S. L. (2010). *The case of tomato in Ghana: Productivity* (No. 19). International Food Policy Research Institute (IFPRI).

Rost, T. L. (1996). Tomato anatomy. *Available in http://www-plb. ucdavis. edu/labs/rost/tomato/Reproductive/anat. html [08.08. 2011]*.

Sacco, A., Frusciante, C. M. P. L., Lorito, C. M. P. M., & Di Matteo, D. A. (2008). Genetic mechanisms underlying tomato quality traits. *Università Degli Studi Di Napoli Federico II*, 1-16.

Salaria, N. (2012). Meaning of the term descriptive survey research method. *International Journal of transformations in business Management*, *1*(6), 1-7.

Sandhya. (2010). Modified atmosphere packaging of fresh produce: Current status and future needs. *LWT-Food Science and Technology*, *43*(3), 381-392.

Sarma, P. K., & Ali, M. H. (2018). Value Chain Analysis of Tomato: A Case Study in *Jessore* District of Bangladesh. *International Journal of Science and Research*. ISSN: 2319-7064.

Schmitz, H. (2005). *Value chain analysis for policy-makers and practitioners*. Hague: International Labour Organization.

Senevirathna, P. A. W. A. N. K., & Daundasekera, W. A. M. (2010). Effect of postharvest calcium chloride vacuum infiltration on the shelf life and quality of tomato (cv.'Thilina'). *Ceylon Journal of Science (Biological Sciences)*, *39*(1).

Shahi, N. C., Lohani, U. C., Chand, K., & Singh, A. (2012). Effect of Pre-cooling Treatments on the Shelf life of Tomato in Ambient condition. *An International Journal of Food, Agricultural and Veterinary Sciences, 2*(3).

Sharma, D. A. (2016). Practices and treatment techniques. *Worlds Journal of Innovation in Forest & Agriculture Science*, *1*(1), 23.

Soyk, S., Lemmon, Z. H., Oved, M., Fisher, J., Liberatore, K. L., Park, S. J., & Van Eck, J. (2017). Bypassing negative epistasis on yield in tomato imposed by a domestication gene. *Cell*, *169*(6), 1142-1155.

Suparlan, H. J., & Itoh, K. J. (2003). Combined effects of hot water treatment (HWT) and modified atmosphere packaging. (MAP) on quality of tomatoes. *Packaging Technology and Science, 16*(4), 171-178.

Swetha, K., & Banothu, L. (2018). *Alternatives Technologies for tomato post – harvest quality preservation*: *A Journal of Pharmacognosy and photochemistry*. Pradesh: India.

Swetha, K., & Banothu, L. (2018). Alternative technologies for tomato post-harvest quality preservation. *Journal of Pharmacognosy and Phytochemistry*, *7*(6), 1678-1682.

Tigchelaar, E. C. (1986). Tomato breeding. *Breeding Vegetable Crop*, 135-171.

Ugonna, C. U., Jolaoso, M. A., & Onwualu, A. P. (2015). Tomato value chain in Nigeria: Issues, challenges and strategies. *Journal of Scientific Research and Reports*, 501-515.

Ugonna, C., Jolaoso, M. A., & Onwualu, P. A. (2015). Tomato Value Chain in Nigeria: Issues, Challenges and Strategies. *Journal of Scientific Research and Reports*, *5*, 62-75.

Ugonna, C. U., Jolaoso, M. A., & Onwalu, A. P. (2015). Tomato value chain in Nigeria: Issues, challenge and strategies. *A Journal of Scientific Research and Report, 7*(7), 501– 515.

Van der Hoeven, R., Ronning, C., Giovannoni, J., Martin, G., & Tanksley, S. (2002). Deductions about the number, organization, and evolution of genes in the

tomato genome based on analysis of a large expressed sequence tag collection and selective genomic sequencing. *The Plant Cell*, *14*(7), 1441-1456.

Wahome, P. K. (2019). The management of post-harvest losses of tomato in developing countries. *UNISWA Journal of Agriculture*, *20*, 45-67.

Wang, F., Smith, A. G., & Brenner, M. L. (1994). Temporal and spatial expression pattern of sucrose synthase during tomato fruit development. *Plant Physiology*, *104*(2), 535-540.

Wargovich, M. J. (2000). Anticancer properties of fruits and vegetables. *Hort Science, 35*(4), 573-575.

Willcox, J. K., Catignani, G. L., & Lazarus, S. (2003). *Tomatoes and cardiovascular health.* London: Prentice-Hall.

Willcox, J. K., Catignani, G. L., & Lazarus, S. (2003). Tomatoes and Cardiovascular Health. *Critical Reviews in Food Science and Nutrition*, *43,* 1-18.

Yeboah, A. K. (2011). *A survey on postharvest handling, preservation and processing methods of tomato (Solanum lycopersicum) in the Dormaa and Tano South Districts of the Brong Ahafo Region of Ghana* (Doctoral dissertation).

Appendix - "A"

QUESTIONNAIRE FOR FARMERS

Topic:

Post-Harvest Handling Practices, Treatment Methods and Challenges Facing Tomato Farmers and Retailers in the Upper West Region of Ghana

This questionnaire seeks to obtain information on Post-Harvest Handling Practices, Treatment Methods and Challenges Facing Tomato Farmers and Retailers in the Upper West Region of Ghana. You are assured of confidentiality as your responses and any other information given out will remain anonymous. We are most grateful for taking the time to answer the questions below, and this questionnaire will take about 10 minutes to complete.

Please tick (√) where applicable

Section A: Demography of Respondents

1. What is your age range? Below 18 years ( ); 18 – 24 years ( ); 25 – 40 years ( ); 41 -55 years ( ); Above 55 years ( )
2. What is your Sex: Male ( ) Female ( )
3. What is your Nationality? Ghanaian ( ) Non Ghanaian ( )
4. What is your Marital status? Married ( ); Divorced ( ); Widowed ( ); Separated ( ); Single ( ).

Section B: ***Post-harvest handling practices of tomatoes by farmers and retailers in the Upper West region of Ghana.***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Items*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	Tomatoes are usually matured reddish (ripped) before harvesting					
2	Tomatoes are more often harvested in the morning					
3	Tomatoes are often harvested and heaped on the ground before selling to retailers					
4	Farmers do clean and disinfect their tomato produce after harvesting					
5	Tomato produce are often sorted and graded after harvesting					
6	Tomato farmers do precool their tomato produce before transporting					
7	There are poor transportation networks leading to tomato farms					
8	Farmers in my community often get training in post-harvest management of tomatoes					
8	Farmers do not have refrigerated vans to transport their produce					
9	Farmers do place their tomato produce in wooden crates for sales					
10	Tomatoes are usually placed in woven baskets for sale to middlemen					

11	Tomatoes are often placed in buckets for sale to traders
12	Farmers often transport their tomatoes using motor bicycles/tri-cycles
13	Most farmers used trucks/pick-up to convey their produce to market centres
14	Tomatoes farmers transport their produce by heads to the market centres
15	Your tomato farm is far away from the market centres
16	Tomatoes usually take long duration before they are bought by buyers/ traders
17	The hand-picking method mainly used by farmers delays the harvesting process

Section C: ***Causes of post-harvest loss of tomatoes and the challenges faced by tomato handlers in the food value chain in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	I faced massive losses in my tomato production					
2	These losses occur through infestation of pests and diseases					
3	There is lack of financial support to tomatoes farmers					
4	Tomato farmers do not receive technical support services					
5	Tomato farmers receive low prices for their harvest					
6	There is limited available ready market for tomato farm					

	produce.
7	Tomato farmers have inadequate storage facilities
8	Tomato farmers have inadequate storage technology
9	Tomato farmers do not have modern farming practices
10	There are inadequate processing plants/ factories for tomato produce
11	Harvested tomatoes have singular use
12	Tomato farmers used genetically modified seeds
13	Farmers of tomatoes do fumigate their tomato plants/farms
14	The variety of tomato seeds used by farmers leads to post-harvest losses
15	Tomato produce have peak and off-peak season
16	Tomato farmers used inappropriate tools in harvesting
17	Tomato farmers used in appropriate containers (sharp-edged) in handling their produce

Section D: ***Treatment methods and strategies that can be used by tomato handlers to minimize post-harvest losses and reduce the challenges faced by tomato handlers and retailers in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	There are varied challenges facing tomato farmers					
2	There is lack of effective irrigation facilities for tomato farmers					
3	Tomato farmers are faced with a lot of pests and diseases infections					
4	Farmers produce tomatoes in insufficient quantities					
5	Locally produced tomatoes are of low quality relative to imported ones					
6	Farmers harvest tomato produce at the inappropriate stage/period					
7	Most farmers do harvest their tomato produce under excessive field heat.					
8	Farmers of tomatoes lack the necessary storage facilities.					
9	Farmers uses inappropriate packaging materials in transporting their tomatoes					
10	Tomatoes farmers harvest their produce under poor/bad field sanitation					
11	Farmers used inappropriate means of transport in transporting tomato produce to markets.					
12	There are poor/bad transportation networks from tomato farms to market canters					

13	Tomato Farmers are faced with the problem of reliable market for their farm produce
14	Tomato farmers lack technical knowledge and support from technocrats.
15	Farmers do sell their tomato produce right on the farm to traders
16	Tomatoes sold on the farms command low prices
17	Farmers face high cost of production of tomatoes

Section E: ***Challenges of Post-harvest Losses of Tomatoes in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	There are various treatment methods of tomatoes					
2	Tomato farmers freeze their produce before selling					
3	There are many processing factories that canned tomato produce in my district					
4	Farmers adopt drying as a treatment method of preserving tomatoes before sales					
5	Farmers in my district are familiar with edible coating as a treatment method of preserving tomatoes					
6	Irradiation is commonly used as a treatment method of tomatoes in my district					
7	Farmers are conversant with chemical (sodium hypo chloride) treatment as another alternative of preserving tomatoes					
8	Tomatoes farmers have been using gaseous treatment as another method of preserving tomatoes.					

Appendix - "B"

QUESTIONNAIRE FOR RETAILERS

Topic:

Post-Harvest Handling Practices, Treatment Methods and Challenges Facing Tomato Farmers and Retailers in the Upper West Region of Ghana

This questionnaire seeks to obtain information on Post-Harvest Handling Practices, Treatment Methods and Challenges Facing Tomato Farmers and Retailers in the Upper West Region of Ghana. You are assured of confidentiality as your responses and any other information given out will remain anonymous. We are most grateful for taking the time to answer the questions below, and this questionnaire will take about 10 minutes to complete.

Please tick (√) where applicable

Section A: Demography of Respondents

1. What is your age range? Below 18 years ( ); 18 – 24 years ( ); 25 – 40 years ( ); 41 -55 years ( ); Above 55 years ( )
2. What is your Sex: Male ( ) Female ( )
3. What is your Nationality? Ghanaian ( ) Non Ghanaian ( )
4. What is your Marital status? Married ( ); Divorced ( ); Widowed ( ); Separated ( ); Single ( ).

Section B: *Post-harvest handling practices of tomatoes by farmers and retailers in the Upper West region of Ghana.*

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Items*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	Tomatoes are usually matured reddish (ripped) before they are sold to retailers					
2	Tomatoes are more often harvested in the morning					

	before they are bought by retailers
3	Tomatoes are often harvested and heaped on the ground before retailers buy them
4	Farmers often sort and grade tomatoes before selling to retailers after harvesting
5	There are poor transportation networks leading to tomato farms
6	Retailers do not have refrigerated vans to transport their produce
7	Retailers do place their tomato produce in wooden crates for sales
8	Tomatoes are usually placed in woven baskets before they are being sold to customers
9	Tomatoes are often placed in buckets before they are being sold to customers
10	Traders often transport their tomatoes to the market centres using motor bicycles/tri-cycles
11	Most retailers used trucks/pick-up to convey their produce to market centres
12	Tomatoes retailers transport their produce by heads to the market centres for sale to customers
13	Tomato farm is far away from the market centres
14	Tomatoes usually take long duration before they are

	bought by customers in the market centres

Section C: ***Causes of post-harvest loss of tomatoes and the challenges faced by tomato handlers in the food value chain in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	I faced massive losses in my tomato retailing business					
2	These losses occur through mechanical damages and bruises caused by bad packaging and bad nature of roads					
3	There is lack of financial support to tomatoes retailers					
4	Retailers do not receive technical support services					
5	Tomato retailers buy produce from farmers at high prices					
6	Tomato retailers sell produce to customers in the market centres at low prices.					
7	There is limited available ready market for tomato produce.					
8	Tomato retailers have inadequate storage facilities					
9	Tomato retailers have inadequate storage technology					
10	Harvested tomatoes have singular use					

11	Tomato retailers used inappropriate containers (sharp-edged) in handling their produce

Section D: ***Treatment methods and strategies that can be used by tomato handlers to minimize post-harvest losses and reduce the challenges faced by tomato handlers and retailers in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	There are varied challenges facing tomato retailers					
2	There is always shortage of tomato supply in the market centres					
3	Tomato retailers are faced with a lot of pests and diseases infections					
4	Locally produced tomatoes are of low quality relative to imported ones and as a result do not sell fast					
5	Tomatoes are harvested at inappropriate stage/period					
6	Tomato retailers lack the necessary storage facilities.					
7	Retailers use inappropriate packaging materials in transporting tomatoes to the market centres					
8	Retailers use inappropriate means of transport in transporting tomato produce to markets.					
9	There are poor/bad transportation networks from tomato farms to market centres					
10	Retailers are faced with the problem of unreliable market of tomatoes					

11	Tomato farmers lack technical knowledge and support from technocrats.

Section E: ***Challenges of Post-harvest Losses of Tomatoes in the Upper West region of Ghana***

Indicate which of the following you can confidently do without any assistance

No.	*Questionnaire Item*	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1	There are various treatment methods of tomatoes					
2	Tomato retailers freeze their produce before selling					
3	Retailers are familiar with edible coating as a treatment method of preserving tomatoes					
4	Retailers use irradiation method in treatment method of tomatoes before selling					
5	Retailers are conversant with chemical (sodium hypo chloride) treatment as another alternative for preserving tomatoes					
6	Tomatoes retailers have been using gaseous treatment as another method of preserving tomatoes.					

Appendix - "C"

Interview Guide for Agric Extension Officers

This interview guide seeks to obtain information on Post-Harvest Handling Practices, Treatment Methods and Challenges Facing Tomato Farmers and Retailers in the Upper West Region of Ghana. You are assured of confidentiality as your responses and any other information given out will remain anonymous. We are most grateful for taking the time to answer the questions below, and this interview will take about 30 minutes to complete.

Interview Questions

1. What special focus does the Ministry have on tomato production?
2. Does the Ministry have any records on tomato production in the Region?
3. How does the Ministry rate tomato production in the Region?
4. Would you say that all the tomatoes consumed in the Region are cultivated in the Region?
5. Does the Ministry have data on post-harvest losses of tomato in the region?
6. How would you rate the percentage of post-harvest losses of tomato in the Region?
7. What are the post-harvest handling practices of tomatoes that are used by tomato farmer and retailer to reduce post-harvest loss of tomatoes?
8. What are the best handling practices that you think can help reduce post-harvest loss of tomatoes in this area?
9. What are the major causes of post-harvest losses of tomato in the District / Region?
10. Does the Ministry train tomato farmers in post-harvest storage technology?

11. Is the Ministry aware of any traditional post-harvest practices used by farmers and retailers?
12. Has the Ministry ever researched on the efficiency of these traditional methods?
13. How can the challenges faced by Tomato handlers within the food value chain be addressed?
14. What treatment methods can you recommend to tomato farmers and retailers to help significantly reduce Post-harvest losses?