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Evaluating Indigenous Knowledge in Reducing Tomato PHL in Morogoro Region: Case Studies from Mvomero and Morogoro Districts

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ABSTRACT

Tomatoes are one of the most widely consumed vegetables in sub-Saharan Africa, valued for their essential vitamins and minerals. This study assessed the effectiveness of Indigenous Handling Practices (IHP) in reducing post-harvest losses (PHL) in the tomato subsector. Specifically, it examined indigenous handling methods, growers' perceptions, and factors influencing the adoption of these practices. The study involved 100 respondents and 15 key informants who provided valuable insights both qualitative and quantitative analysis techniques. Qualitative data were analysed through content analysis, while quantitative data were subjected to descriptive analysis. The findings reveal that IHP is accessible, cost-effective, environmentally friendly, and culturally significant, with fewer health risks compared to Modern Handling Practices (MHP). The study recommends harmonizing Indigenous and Modern Post-Harvest Loss Technologies (IPHLT and MPHLT) to minimize adverse effects. Additionally, stakeholders of tomato subsector with the government and local government should advocate farmers on commercializing tomato products that are handled through IHP while adopting environmentally friendly technologies.

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ABBREVIATION

CAS	Controlled Atmospheric Storage
DIT	Diffusion of Innovation Theory
FYDP	Five Years Development Plan
HPP	High Pressure Processing
IHP	Indigenous Handling Practices
IKS	Indigenous Knowledge System
IPHLT	Indigenous Post- Harvest Loss Technology
MAP	Modified Atmospheric Packaging
MHP	Modern Handling Practices
MKS	Modern Knowledge System
MPHLT	Modern Post- Harvest Loss Technology
NAP	National Agricultural Policy
PHL	Post Harvest Losses
SDG	Sustainable Development Goal
URT	United Republic of Tanzania

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CHAPTER ONE
INTRODUCTION

1.1 Background Information

PHL can be defined as a measurable quantitative and qualitative loss of a given product at any moment along the post-harvest value chain (De Lucia and Assennato, 1994). Kader et. al. (2012) reported that one-third of the food produced is wasted in developed and developing countries, which accounts for 1.3 billion tons per year. In medium and high-income countries, food is discarded while it is still suitable for human consumption. In developing countries, food losses occur early in the food supply chain at post-harvest and processing stages.

Africa is considered one of the continents with greater arable land suitable for agricultural production than in other continents. The net food production per annum is over 560 million tons. However, the greater portion of this amount is lost due to various factors such as poor infrastructure, low levels of post-harvest technology, pests, inadequate policies and inadequate storage facilities (Siger et.al. 2014). One of the crops that are produced in large quantities is tomato, which plays a vital role in meeting domestic and nutritional food requirements, income generation, foreign exchange earnings and employment creation (Gonzalez, 2017).

According to URT (2020), Tanzania is one of the biggest producers of tomatoes in Africa. In 2020, Production of tomatoes in Tanzania was 329,907 tons, of which 329,078 tons were produced by smallholder farmers and 829 tons by large-scale farmers. The report further shows that, among the horticultural crops in Tanzania, tomato is one of the big three crops that is doing the best in terms of production in the country after banana and mango. The annual productions of such vegetables are Onions (64,007 tons), cabbage (35,156 tons), watermelon (68,687 tons) and Okra (44,325 tons). Others are banana (2,039,433 tons), Mango (526,518 tons), orange (162,691 tons) and pineapple (114,263 tons).

Tomato is one of the famous spices in the domestic cooking, especially in the sub-Saharan countries. It is suggested that each dish served at the household level should include the recipe (Mutayoba and Ngaruko, 2018). According to Nyam *et al*, (2018), tomatoes are used for a variety of dishes and are also processed in the form of various products such as tomato juice, puree, cocktail, paste, ketchup, sauce, jelly, soups, powder and tomato chutneys carotenes, organic acids and phenolic. Tomatoes are rich in vitamin C and antioxidants, mainly lycopene.

Despite its importance and necessity, tomato is one of the perishable products that need intensive care for it to survive longer. Most producers, who are small-scale farmers at a large share, prefer using indigenous knowledge (IK) to serve these purposes.

Practical experience has shown that the supply of tomatoes in the market is uneven such that during dry seasons the level of productivity tends to be high as majority of tomato growers experience high rate of post-harvest loss and the vice versa is true during rainy season. This has caused a kind of inconsistency in the market and financial instability among the tomato growers (Arah, *et al* 2016).

Morogoro region as a case study accommodates thousands of smallholder farmers who engage in tomato production. Some of the leading district councils in tomato production include Mvomero, Kilosa and Morogoro rural. Tomato, as a horticultural crop, is grown for both domestic markets and export markets particularly in the East Africa Region. However, tomato production in the respective region is constrained by several factors. Some of the dominant factors include inadequate storage facilities, lack of proper market information, poor post-harvest spoilage micro-organisms and cultivars disposition to diseases leading to high PHLes of tomatoes.

Presence of indigenous post-harvest technologies in the respective district councils provides room for tomato growers to use them for the sake of reducing PHLes. Application of such technologies intends to maintain the quality and protect the nutritional values of tomato produce. This involves a number of interrelated activities from harvest to sorting, grading, preservation packaging processing, marketing and acceptability of the product by the relevant consumers.

This study, therefore intended to assess the effectiveness of such technologies in improving the quality of tomato products and enhancing the capacity of tomato growers to access profitable markets with reliable customers. Positive response from the respondents will imply recognition of the contribution of indigenous post-harvest handling practices for enhancing productivity in the respective subsector. Likewise, negative respondents will signify the darkness of such technologies in increasing the rate of PHLes and therefore subjecting them into the poverty circle.

1.2 Problem Statement

Tomatoes are an essential crop for both nutritional and economic reasons in Tanzania, particularly in the Morogoro Region. However, post-harvest losses (PHL) remain a significant challenge due to the crop's perishable nature and insufficient post-harvest management practices. While modern post-harvest technologies: such as improved seeds, chemical preservatives, and cold storage (Sarkar et al., 2015; Bassolino et al., 2013; Sinha et al., 2019), have been introduced, these often fail to accommodate the local needs and preferences of smallholder farmers. As a result, indigenous knowledge (IK) has garnered increasing attention as a potential alternative to modern techniques.

Indigenous methods, including selective picking, sun drying, and the use of charcoal-cooled storage rooms, are culturally embedded and widely practiced (Aluga and Kabwe 2016 & Komolafe et al. 2015). However, their scalability and efficiency remain limited, especially in regions like Morogoro, where climate variability and labour-intensive processes, such as sun drying, can reduce their effectiveness. Moreover, comprehensive data on the long-term efficacy and sustainability of these methods is lacking, raising questions about their overall viability for addressing post-harvest losses.

Despite the prevalence of these practices, research on the effectiveness of indigenous methods in reducing post-harvest losses, particularly in the tomato subsector in Mvomero and Morogoro District Councils, remains sparse. This gap in the literature has left critical questions unanswered regarding how indigenous knowledge can contribute to more sustainable post-harvest management.

This study seeks to bridge this gap by evaluating the effectiveness of indigenous knowledge systems in reducing tomato post-harvest losses. The findings are expected to provide valuable insights into how local practices can complement or enhance modern post-harvest technologies, potentially promoting more sustainable agricultural practices and improving the livelihoods of smallholder farmers.

1.3 Objectives of the Study

1.3.1 General objective

The overall objective of this study was to assess the Effectiveness of Indigenous Knowledge towards reducing PHL in Tomato Subsector in Morogoro Region: Selected Cases of Mvomero and Morogoro District Councils.

1.3.2 Specific objectives

a) To identify the indigenous handling practices for reducing PHL on tomato produce.
b) To explore the attitudes of tomato growers towards the indigenous post-harvest technologies for tomato produce.
c) To assess the contribution of the indigenous technologies on reducing PHL in tomato sub-sector.
d) To examine factors affecting adoption of the indigenous post-harvest technologies in the tomato subsector.

1.3.3 Research Questions

This study was guided by the following research questions: -

1. What are the indigenous handling practices for reducing PHL on tomato produce?

2. How do tomato growers perceive the indigenous post-harvest technologies on tomato produce?
3. How effective the indigenous technologies on reducing PHL in tomato sub-sector?
4. What factors affecting the adoption of the indigenous post-harvest technologies in tomato produce?

1.4 Justification of the Study

Various studies (Hailu and Derbew, 2015; Ngubo, 2021) have shown that post-harvest technologies are essential for reducing PHL in agricultural communities. Specifically, the use of local post-harvest handling practices has brought positive changes in the livelihood of tomato producers and their partners. This has opened the room for reducing food losses and protects the nutritional values of tomato products. The reported findings from the studies reveal that appropriate local post-harvest technologies enable farmers to experience significant changes in agricultural productivity.

The obtained findings, inform the government especially through some institutions and policies, which deal directly with small scale farmers. Such Institutions include The Ministry of Agriculture (through extension services), Tanzania Agricultural Research Institute (TARI) for validation, on how to improve indigenous preservation methods. Through policies such as the Agricultural Sector Development Program (ASDP-II), the government recognizes and promotes the use of local knowledge in agricultural processes. ASDP-II provides frameworks for adopting low-cost, sustainable technologies that are compatible with the practices smallholder farmers already know and use. The studies also inform on various financing mechanisms, such as the Agriculture Development Bank of Tanzania (TADB), which provides loans to farmers. These funds are often used to invest in affordable preservation technologies, including improvements to traditional methods. By offering grants and loans groups of farmers or cooperatives, the government enables communities to purchase materials and tools that facilitate indigenous preservation techniques, such as building improved drying platforms or constructing locally designed cold rooms.

Moreover, the findings intend to inform the smallholder farmers who engage in production of tomato and other horticultural products on the necessity of applying indigenous post-harvest technologies since the current market forces support products that have fewer chemicals and other environmentally friendly. The decision to focus on such technologies can enable them to maintain the quality of their produce and thus access more profitable markets that can ensure higher earnings for the producers and other participants found in the value chain.

From the institutional perspectives, this study is in line with the National Agriculture Policy (NAP) URT, (2013) which insists on the application of desirable indigenous post-harvest practices for the sake of maintaining quality and ensuring higher productivity. The study also is part and parcel to the National Five Years Development Plan 2021/22 – 2025/26 on the application of science, technology and innovation to improve productivity and yields in the agriculture sector (URT, 2021). At the international level, the study is in line with the Sustainable Development Goals SDG's 2030: goal 9, target 3 (Increase the access of small-scale industrial and other enterprises, in developing countries, to financial services, including affordable credit, and their integration into value chains and markets).

1.5 Definition of Key Terms

a) **Effectiveness**: It measures success in achieving a clearly stated objective (Cochrane *et al.*, 1980). In this study, the term effectiveness focuses on changes that tomato growers experience after using indigenous post-harvest technologies. The respective technologies are effective when they bring positive changes in the livelihood of growers.

b) **Indigenous Knowledge**: It is understood as local or traditional knowledge that is transmitted in a particular society over decades/centuries via oral tradition. This knowledge is used for improving people's lives, particularly the marginalized people (World Bank, 1998). A similar definition has been used in this study.

c) **Post-harvest Losses**: It is defined as the measurable quantitative and qualitative loss of products at any point in the post-harvest chain, from harvest to consumption (Kikulwe *et al.*, 2018). A similar definition has been used in this study.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

In the literature, post-harvest loss (PHL) accounts for three major issues: quantitative loss, qualitative loss and food waste. These losses elevate from the time of harvesting to the time of consumption. Spurgeon (1977) considered the term post-harvest as the whole chain from harvesting to the consumer's preference with minimum loss, maximum efficiency and maximum return for all involved. Also, (Kikulwe *et al.*, 2018) defined it as the measurable quantitative and qualitative loss of products at any point in the post-harvest chain, from harvest to consumption. Alonso *et al.* (2010) denote that the post-harvest loss of tomatoes has been repeatedly experienced despite the availability of modern technologies like canning, branding, powdering and the like. It has been noted that a high percentage of tomatoes are discarded every year due to PHL resulting from the nature of this type of horticultural crop of high moisture content and high perishability. Despite constantly addressing the technical solution literature shows an insufficient alternative approach to the problem. This study has addressed the role of IK in solving the problem of post-harvest loss through harmonization with the available technology. The study is limited to the issues of integrating the Indigenous knowledge of PHL in the tomato sub-sector and specifically accounting for the way farmers choose to adopt or not to adopt the IK on handling the ready-harvested tomato produce.

2.1 Theoretical Literature Review

2.1.1 Diffusion of Innovation Theory (DIT)

The diffusion of innovations theory was developed by E.M. Rogers (2003), a communication theorist at the University of New Mexico, in 1962. The theory explains the passage of a new idea through stages of adoption by different people who participate in or begin using the new idea. Rogers, (2003) explained the five stages on adopting an innovation among the community. The five stages include knowledge, persuasion, decision, implementation, and confirmation as seen in Figure 1.

- ✓ **Knowledge Stage:** This stage involves learning new methods by actively seeking information about what needs to be done, how to do it, and why it is necessary. According to Rogers (2003), individuals in this phase strive to understand the nature of the innovation, its operational mechanisms, and the reasons for its effectiveness. In the context of indigenous knowledge for reducing tomato post-harvest loss, this stage represents when farmers and stakeholders become aware of the issue, learn practical applications, and grasp the underlying principles essential for successful implementation.

- ✓ **Persuasion stage**: is the level whereby one is involved more sensitively with the innovation. It is the place where the attitude of the adopters is determined. Rodger states that, whereas the knowledge stage is more cognitively centred, the persuasion stage is more emotional or feeling-centred. It is the place where media information or peer influence takes its shape. Sherry (1997) addressed that, while information about new innovations is usually available from outside experts and scientific evaluations, teachers usually seek it from trusted friends and colleagues whose subjective opinions of new innovations are most convincing.
- ✓ **Decision stage**: This level is where one decides or rejects the innovation. The rejection has either active or passive rejection. According to Rogers, an active rejection is where an individual tries an innovation and thinks about adopting it but later on he or she decides not to adopt it. In passive rejection, the individual does not consider adopting the innovation at all.
- ✓ **The implementation stage**: the innovation is put into practice, however, the uncertainty about the outcomes of the innovation still can be a problem at this stage. The technical assistance is still vital at this stage; and there might be reinvention which will include some modifications (Rogers, 2003). He further discussed that, the more reinvention takes place, the more rapidly an innovation is adopted and become institutionalized.
- ✓ **The confirmation stage**: Subject to the decision to the innovation, in this stage, the adopter is looking for support upon the decision made. This decision can be reversed if the individual is exposed to conflicting messages about the innovation (Rogers, 2003). Therefore, one may have later adoption or discontinuance. Discontinuance may be choosing the alternative innovation replacing it (replacement discontinuance). The other type is disenchantment discontinuance whereby the party rejects the innovation because the expected performance.

Robinson (2009) summarizes the stages into what he called three valuable insights for a social change. These were classified as the qualities of innovation, peer-to-peer conversations and networks, and understanding the needs of different user segments. This model is in line with the indigenous knowledge on the PHL on Tomato Handling Practices (PHLTHP) with the objectives of increasing the tomato shelf life. The adoption of IK on post-harvest handling practices has been measured through the five stages of DIT. The adopters' behaviors have shown to be influenced by output of the innovation through the stages.

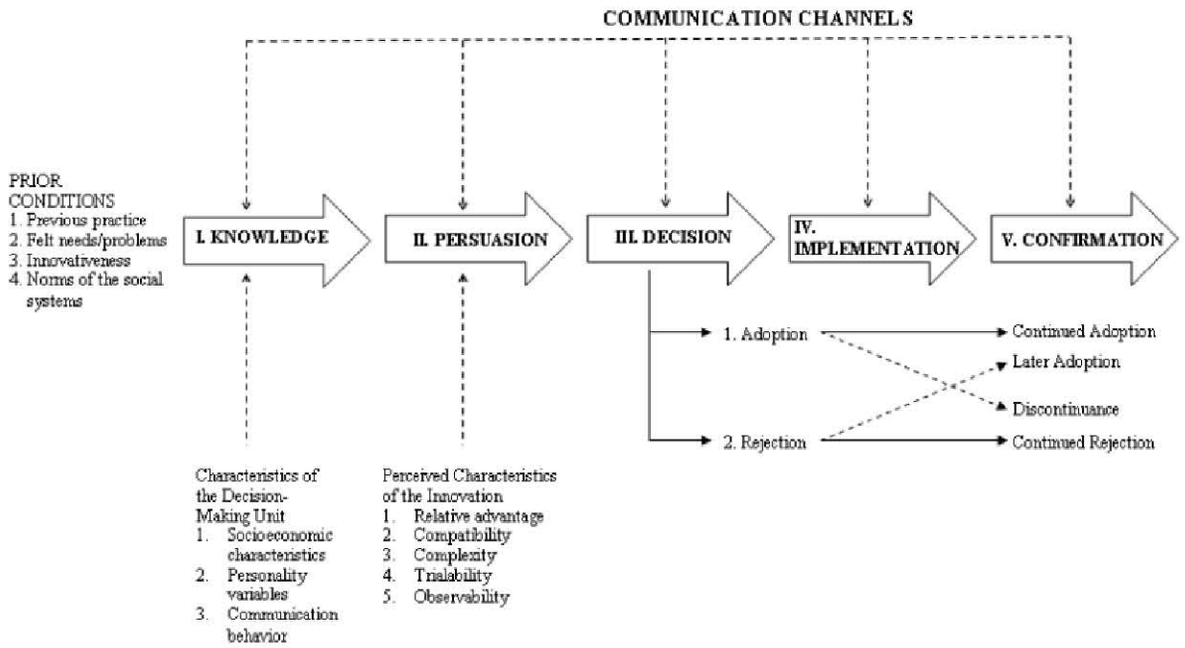

Figure 1: A Model of Five Stages in the Innovation-Decision Process, *Source: Adopted from Sahin, (2006).*

2.2 Empirical Literature Review

2.2.1Tomato production

Tanzania is a leading tomato producer in Africa, with a total production of 329,907 tons in 2020. The vast majority of this, about 329,078 tons, came from smallholder farmers, while large-scale farmers contributed just 829 tons (URT, 2020). This highlights the dominance of smallholder farming in the country's tomato production sub- sector. Among the country's top horticultural crops, tomatoes rank highly alongside bananas and mangoes (URT, 2020). Other important crops include onions, cabbage, watermelon, and okra.

Tomato is a staple in domestic cooking, especially in sub-Saharan Africa, where it is a common ingredient in almost every household dish (Mutayoba & Ngaruko, 2018). Beyond its culinary uses, tomatoes are processed into various products such as juice, puree, paste, ketchup, and sauces, as well as soups, chutneys, and powders. They are also valued for their nutritional content, being rich in vitamin C and antioxidants like lycopene, which have health benefits (Nyam et al., 2018).

However, tomato is suffering from the PHL due to its nature of perishability. Practical experience has shown that the supply of tomato in the market is uneven where during the dry season the level of productivity tends to be high as majority of tomato growers

experience high rate of PHL and the vice versa is true during the rainy season. This has brought a kind of inconsistency in the market and financial instability among the tomato growers (Arah *et al,* 2016). Despite the argument from the literatures on tomatoes' perishability; tomatoes ubiquitous use in cooking increases the importance of reducing post-harvest losses. The widespread usage should link directly to the economic and food security consequences of PHL. Therefore, this study assumed IKS related to cooking, such as traditional methods of preservation (drying or fermenting tomatoes) that prevent spoilage and waste.

Tomato (Lycopersicon esculentum Mill.) is a soft fruit, has a very short shelf life. Environmental factor decreases its quality and shelf life like microbial diseases and high respiration and transpiration rate (Vignesh and Nair, 2019). After harvesting a tomato fruit, its quality like firmness, colour, taste, and moisture content rapidly changes (Zanetti et al., 2018). There is approximately 20 to 50% loss of fruits during improper storage and poor handling of fruits in developing countries (Manoj et al., 2016). There has been a long discussion on how tomatoes should be preserved to increase their shelf life. Tomato can be processed in various products such as tomato juice, puree, cocktail, paste, ketchup, sauce, jelly, soups, powder and tomato chutneys carotenes, organic acids and phenolic (Nyam, *et al*, 2018). Other literatures report on decrease in tomato quality after some interventions with certain chemicals as preservatives. It is reported that, the experiment done to include preservatives, such as concentrations of sodium benzoate (0.05 and 0.1%) and potassium metabi-sulphate (0.05 and 0.1%) also stored at 25°C, 4°C and -10°C decreased the quality of lycopene, beta-carotene and ascorbic acid during storage period (Sarkar et, al., 2015; Okorie et al, 2004). Rutta (2022) reported that lack of cold storage facilities is one of the leading causes of massive post-harvest tomato losses, negatively affecting farmers' livelihoods and the sector's economic contribution. The inconsistency and corruptibility in tomato production calls for a new study to investigate the way familiarity and cultural backgrounds with the local people and some sort of inclusivity could reduce the problem of PHL in tomato production.

Some few studies have addressed the use of natural remedies for increasing the shelf life of tomatoes. For instance, Jafari et al., (2017) got a positive result of original taste after associating the tomato paste with microencapsulated olive leaf extract. According to Nasar *et al.*, (2023), the use of Aloe Vera and turmeric showed a positive result on increasing the shelf life of tomatoes. Bio-preservation is a novel technique for the preservation of food products by the utilization of natural antimicrobial substances to increase the shelf life of fruits and vegetables. Nowadays, consumers do not have an interest on chemical preservation due to its toxicity and health hazards (Mohammed et al., 2017).

2.2.2 Causes of PHL in tomatoes

According to Arah et, al. (2015), causes of PHL can be categorized into two groups that is: on- farm causes and off- farm causes. The off- farm causes include all the operations aligning to the loss of crops during the act of harvesting, while the off- farm causes are those related to off- farm infrastructure like transportation, roads, processing and marketing. Other reports on the causes to be categorized as primary and secondary causes (Aidoo et al., 2014). While the primary causes of PHL have been identified as rot, bruises, disease and pests' damage, poor handling; secondary causes have been identified as poor varieties, transport problems and poor harvesting technique.

One of the studies on PHL of tomatoes in Bangladesh by Sarma (2018), identified major causes with percentage of PHL to be: processing technology of tomato 83.3%, insufficient services support from extension officers: 70%, low demand for dried tomato :50%, high agricultural labour force :30%, pest and diseases :25% and insufficient market info 20%. It is quite obvious that there is a discussion on how to go about on curbing this problem, which for sure corrupts the real production of tomatoes and delay the ultimate goal of economic growth through the tomato sub sector. In this case the Indigenous Knowledge System (IKS) challenges the Modern Knowledge System (MKS) for sustainable development.

It was also reported that, a variety of tomato can significantly influence PHL. Different varieties have distinct characteristics that can affect their shelf life, resistance to diseases, handling, and storage requirements. This is evidenced by some studies which report that selecting the right variety based on the intended post-harvest handling practices, transport, and storage conditions can significantly reduce losses (Endalew, 2020 & Anaba, 2018). The varieties are measured by their characteristics that support longer shelf life, better disease resistance. Firmer fruits can help farmers, distributors, and sellers minimize post-harvest loss (Sinha et al, 2019; Tigist et al, 2013; Bassolino et al, 2013). According to Osei, (2017) hybrid varieties or commercially bred varieties perform better in terms of reduced post-harvest losses compared to heirloom or local varieties, which might have higher loss rates due to their delicacy and shorter shelf life. Climatic conditions also interact with the variety, meaning certain varieties perform better in specific climates regarding post-harvest retention.

Although some literature discusses environmental factors reduce tomato shelf life, their focus on microbial diseases overlooks the potential influence of post-harvest handling and storage techniques on different tomato varieties. This study investigates the environmental, varietal and social economic factor to provide a more comprehensive understanding of tomato PHL.

2.2.3 Attitudes of tomato growers towards adoption post-harvest technologies

Attitudes of tomato growers towards the adoption of post-harvest technologies play a pivotal role in shaping the effectiveness and sustainability of agricultural advancements aimed at reducing post-harvest losses. Understanding these attitudes provides insights into growers' openness, concerns, and perceived compatibility of modern technologies with traditional practices. Such insights are essential for fostering integration between indigenous knowledge systems and new technologies, ultimately contributing to improved post-harvest management and food security.

Essence of Exploring Attitudes of Tomato Growers towards Indigenous Post-harvest Technologies

The decision to explore an objective focused on understanding the attitudes of tomato growers towards indigenous post-harvest technologies is crucial for several reasons:

Adoption and Usage: The success of any post-harvest technique, whether indigenous or modern, depends on the willingness of farmers to adopt and use it. By understanding growers' attitudes, the study can reveal the factors influencing their decisions to embrace or reject indigenous methods (FAO, 2013). Positive or negative perceptions will directly affect how widely these practices are implemented.

Cultural Relevance: Indigenous knowledge is often deeply tied to local traditions, beliefs, and cultural practices. Investigating growers' attitudes helps assess whether these practices are viewed as valuable, sustainable, and practical within their cultural context. This insight is essential for promoting methods that align with local values and lifestyles.

Practical Barriers: Even if growers appreciate indigenous technologies, they may face challenges such as labour intensity, time requirements, or the need for specific environmental conditions. Understanding attitudes will highlight these practical concerns, which is key to determining why certain practices are favoured or avoided.

Comparison with Modern Techniques: Farmers may have different views on indigenous versus modern technologies. By studying their attitudes, the research can uncover whether they see indigenous methods as more or less effective as modern ones, and why. This helps identify any biases or misconceptions that may influence their preferences and practices. Furthermore, combining indigenous and modern techniques can reduce post-harvest losses more effectively than either system alone. By understanding growers' attitudes, researchers can tailor approaches to foster trust and acceptance, making it more likely for farmers to adopt beneficial practices without losing valuable indigenous knowledge (Thamaga-Chitja et al., 2004).

Improving Adoption Strategies: Understanding farmers' attitudes provides valuable feedback for policymakers and agricultural extension services. If farmers are reluctant to

adopt indigenous practices due to misconceptions or lack of knowledge, then the study can suggest strategies to improve communication, education, and training to enhance the uptake of effective practices (Rogers, et al, 2003).

Sustainability and Long-Term Impact: For any agricultural intervention to be sustainable, it must resonate with the users. If farmers have positive attitudes toward indigenous methods, then they are more likely to maintain these practices in the long term. Assessing their attitudes helps ensure that interventions are not only effective but also socially and culturally sustainable.

By including this objective, the study provided a more holistic understanding of the feasibility, acceptance, and potential for scaling indigenous post-harvest technologies, ensuring that the solutions proposed are both practical and farmer-driven.

2.2.4 Modern Knowledge System (MKS) Vs Indigenous Knowledge System (IKS)

Modern Knowledge System (MKS)

MKS refers to formal knowledge produced in academic institutions, research centres, and industrial firms, and it continues to dominate global development thinking (Hambati & Yengoh, 2018). Various MKS practices have been developed to address post-harvest losses (PHL) in tomato production, including Controlled Atmosphere Storage (CAS), Modified Atmosphere Packaging (MAP), irradiation, edible coatings, High-Pressure Processing (HPP), and freeze-drying.

Controlled Atmosphere Storage (CAS)

This method extends the shelf life of perishable products, such as tomatoes, by modifying the gaseous composition in the storage environment. According to Kader (2013), this technique slows down ripening and aging processes, thus reducing spoilage and maintaining product quality.

Modified Atmosphere Packaging (MAP)

While CAS requires controlled storage environments, MAP alters the gas composition inside individual packaging to extend the shelf life of fresh produce like tomatoes. This technique has proven effective in maintaining product quality (Kader, 2013).

Irradiation

Hallman (2011) notes that irradiation exposes tomatoes to controlled amounts of ionizing radiation to reduce spoilage and delay ripening. This method extends the shelf life without significantly altering the nutritional content, taste, or texture of the product, offering a viable alternative to chemical preservatives.

Edible Coatings

As explained by Kittur et al. (2001), thin layers of edible material are applied to food surfaces to reduce moisture loss, control gas exchange, and enhance microbial protection, thus prolonging the shelf life of fruits and vegetables, including tomatoes.

High-Pressure Processing (HPP)

HPP uses extremely high pressure (100 to 600 MPa) to inactivate microorganisms and enzymes responsible for spoilage. Norton et al. (2008) highlight that this technique preserves the nutritional quality, flavour, and texture of tomatoes while extending their shelf life.

Freeze-Drying

Freeze-drying (lyophilization) removes moisture by freezing the food and using a vacuum to sublimate the ice. Ratti (2001) compares freeze-drying to other drying methods, showing that it retains the structure, flavour, and nutritional value of various foods, including tomatoes, making it a highly effective preservation technique.

Indigenous Knowledge System (IKS)

IKS encompasses the knowledge practiced by local communities over centuries, often transmitted through oral traditions, and is applied to address familiar challenges and decision-making processes (Richey et al., 2021; Rugumamu, 2003). In tomato preservation, indigenous methods used in Africa include selective picking, sun drying, and the use of locally made cold rooms, which use charcoal for cooling (Bello et al., 2018).

Drying

Aluga and Kabwe (2016) note that drying, whether direct sun drying or over a wood fire, is a common technique for reducing moisture content and extending the shelf life of tomatoes. This may involve salting to prevent decay, as seen in practices with mushrooms and tomatoes alike (Okoye & Oni, 2017; Ibnouf, 2012).

Boiling and Storage

Dei (1990) describes methods such as boiling tomatoes and storing them for immediate consumption, while Komolafe et al. (2015) observes that sealing tomatoes with oil or using cold water as a preservation method is also widespread among local farmers.

Although IKS methods such as sun drying, selective picking, and charcoal-cooled storage rooms are resourceful and deeply rooted in cultural practices, they may not fully address the scale of PHL in regions like Morogoro. Climate variability and labour intensity are some challenges these methods face, limiting their efficiency and scalability. Moreover, the absence of long-term data on their efficacy raises concerns about their sustainability (Komolafe et al., 2015). However, integrating these traditional

techniques with modern preservation methods could enhance both effectiveness and accessibility (Akullo et al., 2007).

While IKS provides sustainable and accessible preservation methods, particularly for smallholder farmers, it lacks the scalability and consistency of modern techniques. On the other hand, MKS offers advanced control over food safety and quality, albeit at higher costs and infrastructure demands. A hybrid approach combining the sustainability of IKS with the technological precision of MKS may provide a more comprehensive solution for reducing PHL in tomato production, particularly in regions with significant food security challenges.

2.3 Synthesis

Most of the literature on tomato post-harvest handling are basing on the MKS making less emphasis on IKS. It is obvious that the use of chemical, refrigeration and the like are the lion's share of the things operating for preserving tomato produce. It is quite clear that the modern methods preservatives have a notable contribution to the solution for the PHL. However, the social cultural explanations should not be foregone for a new take-off. Bio- preservation strategies are also needed to be documented because of its unique contribution in protecting the mother earth.

The explanation of hybrid variety as the pro act for the increasing of the tomato shelf life can also be compared with the indigenous varieties which are said to have long shelf life. Another gap which is obvious in literature is the existence of a communication gap between the researchers and the community, whereby the MKS has been proved superior in comparison with the IKS to make the farmers not to feel confident when applying the procedures. This has created mismatch of information to this important sector, which is necessary for economic growth. To have a strong bond of preservation kit, there is a need of harmonization of both technical knowledge and locally owned knowledge.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Description of the study area

The study was conducted in Morogoro and Mvomero District Councils. These two district councils are found in Morogoro region, which is estimated to have 40,000 registered tomato growers who operate in various parts of the region (URT, 2021). Therefore, it is viable to involve tomato growers from the respective district councils because they accommodate sufficient number of tomato growers who experience PHL. High rate of PHL in the tomato subsector implies inability of tomato growers to adopt modern post-harvest technologies for preserving their produce. This situation has encouraged them to rely on indigenous post-harvest technologies, which are simple, affordable and durable.

3.2 Research Design

The study employed a cross-sectional design, which involves interviewing a representative sample of a population at a single point in time. Babbie (1994) reported that cross-sectional research design provides quick results and allows collection of data from groups of different characteristics.

3.3 Targeted Population

The target population of this study were smallholder farmers who engaged in tomato production, agricultural officials from the selected Local Government Authorities (LGA), elders and local leaders from the selected villages.

3.1 Sampling Procedures

3.1.1 Sampling unit

The unit of analysis was smallholder farmers (as individuals) who engaged in tomato production and used indigenous post-harvest technologies to reduce PHL for maintaining quality, increasing nutrition and enhancing productivity.

3.1.2 Sample size

The sample size was determined through the following Yamane's formula (Yunus, 2001)

$$n = \frac{N}{1+N(e)^2} \quad \text{..... (1)}$$

Where;

N = Population size (total number of individuals in the sampling frame)

e = Acceptable level of precision

n = Sample size

In obtaining the representative sample for tomato growers, a proportion of 0.07 (precision level of 7%) was used to indicate medium variability in a population of the

respective respondents. This precision level was adopted to obtain a more conservative sample size, which is relatively larger especially when the sample population appears to be somehow heterogeneous.

Sample size for tomato growers in Mvomero and Morogoro District Councils was determined by setting

N = 5000 and

e = 7% (0.07).

Hence $$n = \frac{5000}{1+5000(0.07)^2}$$

$$205 = \frac{5000}{1+5000(0.07)^2}$$

= 205 (medium but representative sample – medium variability)

The study used 50% of the targeted population sample because being representative in terms of socio-demographic and economic characteristics that were considered during the sample selection. Respondents were distributed as in Table 1.

Out of 205 respondents who deserved to participate in data collection, the study employed simple random sampling technique to select 100 (almost 50%) of the respondents due to financial reasons, where in each village 25 respondents were selected. Simple random sampling was used because the study intended to give all members equal chances to participate.

Table 1: Distribution of Respondents in the Selected Villages

District Councils	Villages	Number of Tomato Growers
Morogoro District Council	Matombo	25
	Mkuyuni	25
Mvomero District Council	Dibamba	25
	Kipera	25
Total		**100**

Source: Field Survey, 2023

3.1.3 Sampling techniques

Purposive sampling was employed to select four villages namely, Matombo, Mkuyuni, Dibamba and Kipera that accommodated tomato growers who use indigenous post-harvest technologies such as solar drying, cooling storage practices and use locally made crates, which have been inherited from their parents and grandparents who could not access modern post-harvest technologies from the relevant suppliers. Majority of farmers living in the respective villages prefer such technologies because of the socio-economic and cultural forces.

Key informants such as extension officers, elders and local leaders were selected purposely because they possessed expertise on research issues being investigated. They used their knowledge and skills to share ideas that enabled the study to generate useful information from them.

3.5 Data Collection Procedures

3.5.1 Primary data

The study employed different tools to collect raw data from the respondents. Semi-structured questionnaire was administered to gather raw data from the tomato growers. From the respective data collection tool, data was collected by using close-ended and open-ended questions from the tomato growers. Key informants' interviews were also used to gather detailed and technical information from the key informants.

3.5.2 Secondary data

Secondary data were gathered from the relevant documents such as policies and published reports from the Ministry of Agriculture, Food Security and Cooperatives, and other responsible institutions such as Agricultural Research Institutes, Agricultural University (SUA) and SIDO.

3.6 Data Analysis

Data were analysed using both quantitative and qualitative techniques. Content analysis was adopted to analyse qualitative data, while quantitative data were analysed using Statistical Package for Social Solutions (SPSS version 20), where descriptive analyses were carried out coherently.

3.7 Ethical Consideration

Informed consent, protocol sensitivity, confidentiality, and other ethical issues are critical to any study (Behi and Nolan, 1995). These moral guidelines are consistent with the suggestions made by Zareef et al. (2021) for fostering participant-researcher trust. Respondent's privacy was prioritised, which aligns with the ethical standards delineated by Goodwin et al. (2020) for research investigations. The study's ethical considerations are consistent with the guidelines for maintaining participant-researcher trustworthiness that have been covered by Burgess et al. (2023) and Stommel and Rijk (2021). The dedication to privacy and confidentiality is consistent with the ethical guidelines for using human subjects in research (Ryen, 2004).

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

The study collected data in Morogoro and Mvomero District Councils, areas known for tomato production where thousands of people in different nods of the value chain are employed. Through data analysis, the study generated findings revealing realities that prevail in the study area.

4.2 Socio-Demographic Characteristics

Findings in Table 2 reveal that the study was conducted in Morogoro and Mvomero District Councils which accommodate tomato producers who use indigenous post-harvest technologies for maintaining quality before the tomatoes reach the market for undertaking business. As per research design, 50% of the respondents came from Mvomero District Council and the rest came from Morogoro District Council.

Table 2: District Councils involved in the study

Local Government Authorities	No	%
Mvomero District Council	50	50.0
Morogoro District Council	50	50.0
Total	**100**	**100.0**

Source: Field Survey, 2023

Apart from the selected district councils, the study involved respondents from four selected villages. In each village, the researchers collected information from 25 respondents. In Morogoro District Council, the respondents were selected from Matombo and Mkuyuni villages, while in Mvomero District Council, the study collected information from Dibamba and Kipera villages.

Table 3: Villages involved in the Study

Villages	No	%
Matombo	25	25
Mkuyuni	25	25
Dibamba	25	25
Kipera	25	25
Total	**100**	**100**

Source: Field Survey, 2023

The study identified that tomato growers in the selected villages, experienced PHL due to their limited capacity to adopt modern post-harvest technologies, which were available in the market. This situation had encouraged them to concentrate on

indigenous post-harvest technologies because of being simple, accessible and environmentally friendly. Proper utilization of such technologies helped them protect the quality of tomato produce and thus manage to access profitable markets within and outside their areas of jurisprudence.

Results in Table 4 depicts that 38% of the respondents were aged between 33-37 years, while 32% of them were aged between 28-32 years of age. Only 10% of the respondents were more than 42 years of age, implying that most of the tomato growers in the study area are youth who have the capacity to produce and feed the markets within and outside the Morogoro region. The capacity to produce tomatoes in large quantities increases the possibility of experiencing PHL due to the absence of appropriate post-harvest technologies. Their decision to adopt local post-harvest technologies came into being as a means of reducing PHL and raising income through business with reliable customers in profitable markets.

Study results indicated that 70% of the respondents were male, while 30% of them were female. This implies that the study opened a room for both male and female tomato producers to participate and share their views and experiences on the role of indigenous post-harvest practices in reducing the rate of PHL in the tomato subsector. In addition, these findings imply that local post-harvest technologies, such as using locally made containers, solar drying, and cooling storage facilities, have been adopted by both male and female tomato growers for the sake of preserving the quality and safety of the tomato fruit as high as possible until it reaches the final consumer.

Findings in Table 4 reveal that majority (75%) of the tomato growers in the study area had attained primary education, while the minority (25%) had attained secondary education. These findings signify that all respondents who participated in the study were literate. Literacy can enable smallholder farmers to adopt desirable agronomic practices for enhancing productivity and thus, improving the standard of their livelihood. Apart from adopting agronomic technologies for boosting agricultural productivity, particularly food and cash crops, literate farmers can also adopt post-harvest technologies for protecting the quality of their produce prior to marketing. Proper use of post-harvest technologies reduces PHL, enhances higher productivity, raises income for the producers and ultimately promotes food security in the respective households/community.

About 69% of the respondents were married, while 26% of them were single. Only 5% of the tomato growers in the study area were divorced. This implies that the majority of the respondents had families. In the African context, family members are considered to be human capital whose participation in agricultural production brings fruitful guarantees

productivity. However, significant changes can be attained when the human capital possesses expertise in the agronomic practices.

Table 4: Socio-Demographic Characteristics of the Respondents

Characteristics		Tomato Producers (n=100)	
		No	%
Respondent's Age (Years)	23- 27	10	10.0
	28- 32	32	32.0
	33- 37	38	38.0
	38- 42	10	10.0
	Over 42 years	10	10.0
Respondent's sex	Male	70	70.0
	Female	30	30.0
Education Status	Primary Education	75	75.0
	Secondary Education	25	25.0
Marital Status	Single	26	26.0
	Married	69	69.0
	Divorced	5	5.0
Land Size	One acre	28	38.0
	Two acres	62	62.0
	Three acres	10	10.0
Production per season	One season	65	65.0
	Two seasons	35	35.0
Experience in Tomato Business	1-3 years	30	30.0
	4-6 years	50	50.0
	More than six years	20	20.0
PHLes per season	0-500 kgs	40	40.0
	501 kgs – 1000 kgs	50	50.0
	More than 1000 kgs	10	10.0

Source: Field Survey, 2023

According to Ndumbaro (2019), indigenous post-harvest technologies are locally made, which require sufficient supply of human labour to use them for protecting the quality of their produce and for accessing reliable markets within and outside their areas of jurisprudence.

Moreover, findings in Table 4 show that 62% of the tomato growers in the study area possess two acres, while 38% own one acre for tomato production and 10% of the tomato growers possess three acres for similar purposes. In addition, 65% of the tomato growers reported producing tomatoes in one season per year, while 35% of them reported producing in two seasons per year. The study was informed that farmers who grow tomatoes in two seasons have the capacity to yield more crops compared to their counterparts who grow in one season. However, the capacity to grow in two seasons relies on the climatic conditions and other physical and geographical forces prevailing in the particular area. Key informants reported that the adoption of post-harvest technologies does not rely on the capacity to produce tomatoes in large quantities. Rather, it focuses on the willingness to avoid unnecessary losses through the protection of tomato fruits, which are highly demanded by the consumers.

Findings depict that 70% of the tomato growers had more than three years' experience in the field. This implies that most of the respondents who participated in the study have enough experience in the field, implying their capacity to share ideas with young farmers for the sake of improving the quality of the produce and the entire production system that could guarantee higher output. Such changes can also be grasped through the adoption of post-harvest technologies, which are aimed at creating an enabling environment for tomato growers to establish proper storage facilities for storing tomato fruits prior to marketing.

Results indicate that 50% of the respondents reported to have lost 501 kgs-1000kgs of tomato produce after harvesting while 40% of them reported to lose less than 500kgs. Only 10% of the respondents reported to lose over 1000kgs. This implies that the majority of tomato growers in the study area experience the problem of PHL in the respective subsector. The existence of this problem limits the capacity of tomato growers to increase productivity and access profitable markets in the country. As a result, some tomato growers have decided to adopt and use the indigenous post-harvest technologies because of their qualities, affordability and simplicity.

4.3 Varieties of Tomato Breed

Findings in Table 5 reveal that 60% of the tomato growers in the study area prefer Assila F1, while 25% of them reported to use Imara F1. About 10% of the respondents reported to use Dhahabu F1, and 5% of them reported to use Mwangaza F1.

Table 5: Varieties of Tomato Breed

Production per season	No	%
Assila F1	60	60.0
Imara F1	25	25.0
Dhahabu F1	10	10.0
Mwangaza F1	5	5.0
Total	**100**	**100.0**

Source: Field Survey, 2023

The study confirms that the self-life and shelf-life of tomato produce is much connected with the tomato variety being used by the respective farmers. Through face-to-face interviews, one of the tomato growers residing in Matombo village, informed that preferences for Assila-F1 and Imara–F1 varieties was based on their capacity to stay for relatively longer periods in the market before getting rotten. This implies that farmers who preferred such tomato variety opted for the indigenous post-harvest technologies because they could preserve their produce for a long time prior to marketing and consumption.

4.4 Challenges Facing Tomato Growers in Selling Tomato

Findings in Table 6 show several challenges, which tomato growers reported to experience when selling their produce to the targeted markets. The leading challenge was high rate of PHL in the tomato sub-sector. About 68% of the respondents reported that tomato growers in the study area experienced high rate of PHL. This problem prevailed because most of them did not possess appropriate storage facilities. This situation affected the quality of tomato and, thus, reduced the price at the market.

Through face-to-face interviews with tomato growers, the study confirmed that farmers in the study area did not have proper storage facilities, rather, they stored their produce in their houses. Such practices reduce the quality of tomato and, thus, create tension in the market where potential buyers are found.

Table 6: Challenges in Selling Tomato

Challenges	No	%
Lack of reliable customers	10	10.0
Dominance of the middlemen	12	12.0
Lack of proper market information	10	10.0
High rate of post-harvest loss	68	68.0
Total	**100**	**100**

Source: Field Survey, 2023

Inability to access proper post-harvest technologies forces tomato growers to sell their produce at low price. Generally, majority of tomato growers have remained to be price takers, since they lack institutional powers to regulate the market so as to create a favourable system that can enable them to generate income to improve their living conditions.

The tendency of selling tomato produce at low prices leads to financial losses as the producers fail to generate sufficient income to re-mobilize resources for the common good. Financial losses force majority of farmers to remain poor and, thus, continue to be members of the poverty circle. This implies that a high rate of PHL does not exist as an independent phenomenon, but it prevails as the causer of other problems that

ultimately affect the wellbeing of tomato growers, their business partners and the entire rural communities.

4.5 Indigenous Handling Practices for Reducing PHL in the Tomato Subsector

Production of horticultural crops provides an opportunity for smallholder farmers to promote food security and compete to access profitable markets within and outside Tanzania. Also, tomato production plays a significant role in human nutrition. However, the respective horticultural crop is associated with practical risks, which reduce its quality and thus leads to PHL. Post-harvest loss is a common challenge in the tomato sub-sector as it causes less food to be available at the market and, thus, contributes to food insecurity. The reduction of PHL in the respective subsector is important to increase food security and maximize profit through accessing profitable markets.

There has been a debate on the efficacy of indigenous post-harvest handling practices. There are scholars who support the application of such practices because of their coherence in protecting nature and maintaining quality for the common good. Other scholars have different opinions, arguing that indigenous post-harvest handling practices go along with inappropriate handling methods, resulting in huge PHL. This situation prevails due to the presence of a knowledge gap in respect of the appropriate post-harvest handling practices among tomato growers. Such practices are reported to insignificantly produce quality loss and thus increasing the possibility of post-harvest decay.

The reported study intended to assess the effectiveness of indigenous knowledge towards reducing PHL in Tomato Subsector. Therefore, it was necessary to involve smallholder farmers who engaged in tomato production in a selected study area; in this case those in Morogoro and Mvomero District Councils. Through face-to-face interviews, the study established that tomato growers in the study area used such practices for reducing PHL. Such practices show how they have helped tomato growers to reduce post-harvest losses and improve the living standards of local producers.

4.5.1 Using local storage facility in the household

Through face-to-face interviews with respondents in Matombo, Mkuyuni, Kipera and Dibamba villages, the study established that majority of the tomato growers in the respective villages were low income and middle-income earners with limited financial capacity. With such a situation, it has become difficult for them to construct modern storage facilities to keep their produce for some days before sending them to the market.

It was further reported that absence of storage facilities forced most of the tomato growers to harvest and sell directly to their buyers either at the farm gate or to the nearby markets within a shorter period of time to avoid the tomatoes getting rotten.

This strategy did not give the growers higher returns because the producers sold their produce at lower prices for the sake of avoiding the risks that could destroy their businesses.

As a means of reducing PHL and maintaining quality of tomato produce, majority of tomato growers in the study area reported to use local storage for storing tomatoes before moving them to the market to sell to their clients. One of tomato growers in Matombo village reported that:

"As a smallholder farmer, I did not have the capacity to construct a modern storage facility. This situation forced me to sell my produce at the farm gate after harvesting. As a result, I did not earn the required profit since the business was dominated by buyers who sat the price for his own benefit. I was forced to sell because I did not want to experience post-harvest losses and other associated risks that could destroy my project. The decision to use one of the rooms in my house was made as a strategy to store my produce in a safe place while searching for profitable markets within and outside Morogoro District Council. This strategy has helped me in reducing post-harvest loss and accessing markets with reliable customers."

Another respondent from Kipera village argued that:

"Since I don't have the capacity to construct a modern storage facility, I have decided to improve one room in my house to be used as a storage facility for storing tomato produce after harvesting. The presence of such local facility has enabled me to store tomato produce for more than three days before moving to the market to sell to my clients. This strategy has brought significant changes in terms of maintaining quality and increasing income at the household level."

The third respondent from Dibamba village added that:

"In my house, I have four rooms. But I have decided to change one room and make it a storage facility for my tomato produce. The room is separate and well-constructed to the extent that it does not permit insects, rats and other related living organisms to enter and destroy the produce. This has provided a chance for the tomato produce to stay for days prior to marketing."

Available findings, it is evident that respondents in the study area affirm that the decision of using local storage facilities in the household has enabled tomato growers to reduce the rate of PHL, promote food security and open more employment opportunities for the local people who engage in different nods of the tomato value chain. Ultimately, such operations play a significant role in raising people's income and securing other livelihood outcomes.

Through face-to-face interviews with extension officers operating in Morogoro and Mvomero District Councils, the study affirmed that local post-harvest handling practices

enable the majority of tomato growers to improve their living conditions by selling quality tomato produce to the market and improving nutrition status at the household level. Such practices have also attracted more youth to engage in tomato production with the same purpose of raising income and improving their living standards.

One of the extension officers in Mvomero District Council reported that:

"Most of tomato growers in the respective district council do not possess modern storage facilities in their residential areas. Therefore, instead of constructing separate facilities for storing tomato produce, they have decided to use some of their rooms for the respective operations. Despite some weaknesses in handling horticultural products, the presence of such facilities has enabled tomato growers to minimize financial losses by reducing the rate of PHL."

The same findings were reported by an extension officer from Morogoro District Council, who argued that: -

"Tomato growers who do not possess local storage facilities experience a number of risks, which lead to financial losses. The decision to use local storage facilities has given them an opportunity to increase productivity and sustain their businesses with reliable clients. Practical changes have been observed in many households whose members participate in tomato production as one of the income generating activities."

Available findings from the respondents and key informants reveal the reality that the use of local storage facilities has played a significant role in promoting agricultural development in the study area, as majority of tomato growers continue to expand the scope of production for the sake of improving nutrition at the household level and improving income for the participants in the value chain.

4.5.2 Improved local containers

The study confirms that tomato growers in the study area use local small boxes or containers to protect tomato produce. With such containers, tomato produce can be easily transported from the place of production to the market/place of consumption. Such containers are made of wood and found to be inexpensive, re-usable for several uses and recyclable. The adoption and use of such locally available and low-cost materials is essential to protect the quality of perishables till consumption.

Through face-to-face interviews with tomato growers, respondents informed that such local technologies are available and accessible at affordable price. One of them said the following:

"The presence of locally made containers in the village enables us to protect tomato produce and access profitable markets on time. Such stuffs are used to store tomato produce and ensure that the quality is maintained for improving nutrition for the final consumers."

Another respondent in Dibamba village reported that:

"Tomato growers can access raw materials for making small wood containers. These crates are simple to be carried by trucks or any other transport facility from the area of production to the place of consumption. The users of such technologies can rarely experience post-harvest losses since the containers are designed to protect tomatoes from wounds, bruising and physical injuries."

Extension officers who participated in the study as key informants affirmed that adoption of such post-harvest technologies have enabled tomato growers to reduce post-harvest losses and maintain the quality of their produce. This implies that tomato growers who use such containers have the capacity to access profitable markets that have reliable customers. Customers of horticultural products prefer items that have good quality and not otherwise. One of the extension officers in Kipera village argued the following:

"The presence of wooden crates enables tomato growers to pack their produce coherently before transporting them to the market for selling. However, the actor is required to sort his produce by separating tomatoes with better grades and those with poor grades. Principally, wooden crates accommodate tomato produce with better grade because the current markets demand quality than quantity."

Through observation, the study identified that tomato growers preferred such technologies because of their simplicity and affordability. Smallholder farmers can easily buy and use them to protect the quality of the produce and ensure that the produce reaches profitable markets. In addition, the respective technology encourages tomato growers to be smart in sorting their produce before packing and sending them to the appropriate markets for commercial purposes. These findings are in line with the work of Karlie (2012) who reported that locally made post-harvest technologies reduce post-harvest losses in tomato subsector and enhance productivity for the betterment of all.

Before the introduction of such locally made technologies, tomato growers in the study area experienced high rate of pre- harvest and post-harvest losses. This situation prevailed because tomato producers did not have the opportunity to use any post-harvest technology whatsoever. As a result, the quality of tomato produces degraded, and the majority of farmers experienced financial losses because of accessing unreliable markets.

One of the senior tomato growers in Mkuyuni village reported that:

Twenty-five years ago, we had plenty of trees in our village, but we did not have the skills to make wooden crates for parking tomatoes before sending them to the market. We did not have time to sort our produce and arrange them in grades. As a result, it was difficult to access good markets because the quality of our produce was extremely poor.

In addition, another senior tomato grower from Kipera village argued that:

"Before the introduction of wooden crates no one in my village was aware that wood could make a crate for parking tomato before transporting them to the market. We used to transport our produce without sorting them into grades, and as a result profitable markets were not accessible at all."

Some key informants, such as Village Executive Officers and Extension officers, had a similar observations that poverty was common in the tomato growers' households because of unfavourable working conditions in the tomato subsector, which limited them from accessing profitable markets that could guarantee higher returns for the producers. Fortunately, the situation is different today where post-harvest technologies are plenty and available in areas of production. Farmers have a role to play in protecting the quality and assessing appropriate markets that could maximize profit for the producers.

One of the village executive officers said the following:

Our local farmers were sceptical with locally made post-harvest technologies because of inferiority complex. Resultantly, most of them experienced high rate of post-harvest losses in the tomato subsector and unfavourable business conditions in the market. Application of simple and accessible local post-harvest technologies has encouraged them to focus more on protecting the quality of tomato produce to capture appropriate market opportunities from reliable customers.

Based on the findings from the field, it is evident that the application of the respective local technologies has helped majority of tomato growers in the study area to reduce the rate of post-harvest losses and maintain the quality of tomato produce prior to transportation and marketing. The adoption of this technology encourages the tomato grower to sort and grade his/her produce prior to packing and sending the products to the market for consumption. This process enables the producer to focus on better grade tomatoes that can fetch higher prices at the market.

4.5.3 Cooling storage practices

Findings from the field revealed that some tomato producers operating in Mvomero District Council applied low energy cool-storage practices for the sake of maintaining quality of their produce and, thus, reducing the possibility of experiencing post-harvest losses. Researchers managed to observe on-farm low-cost cooling technology made up of bricks, sand and bamboo/small trees. Assuredly, the respective technology is made up of local materials that can easily be accessed at lower costs.

Through conversation with tomato growers, it was noted that such technology does not require electricity, rather it requires local materials that are available in the peripheries. The price of such materials is affordable and costs of constructing the respective facility

is also low. Therefore, tomato producers who intend to avoid risks associated with the post-harvesting operations can invest in such a technology for the common good.

Through interviews with one of the tomato growers in Dibamba village, it was revealed that:

"The respective storage facility has cool chambers that reduce temperature by 10^0Centigrade and maintains high humidity of about 95%, which can increase shelf life and retain quality of tomato produce."

Similar response was given by one expert from SIDO who reported that:

"Low temperature storage can protect non observable qualities such as texture, flavour, aroma and nutrition in the harvested tomato. This implies that such practices extend shelf life and enables tomato handlers to maintain quality because tomatoes can survive for a long time when they are stored below the temperature of 10^0 centigrade."

Convincingly, the application of low energy cool storage practices is more accurate than other local practices. However, fewer tomato growers reported to apply such practices because the construction of such facility needs expertise from qualified personnel. Construction materials are available, but the construction process is tedious and therefore needs experts to undertake such activities. Only tomato growers with sufficient financial resources can easily access such local technologies for protecting their produce.

One of the tomato growers in Kipera village reported that:

"I admit that low energy cool storage practice is among the best strategies for reducing post-harvest losses in the tomato subsector. However, in our village we do not have local experts who can deploy such technology and disseminate such skills to others. Those who have adopted such practices have experienced positive changes in their livelihood."

Based on the foregoing findings, tomato growers in the study area need to adopt the respective technologies and use them for enhancing productivity. The main reason for low rate of adoption is the shortage of experts who can disseminate this technology for more beneficiaries so that the entire community of tomato growers could benefit for the public good.

4.5.4 Use of solar drying

Findings from the field reveal that tomato producers in the study area reported to use solar drying practices as a means of protecting the quality of tomato and thus reducing the rate of PHL in the respective subsector. Respondents revealed that through the solar drying system, tomato growers can maintain the nutritional value of the produce.

During face-to-face interviews with tomato growers operating in Mvomero and Morogoro District Councils, the study confirmed that the sub drying method is common in rural areas and rural farmers have been using it for decades.

One of tomato growers who participated in the study revealed that:

"Solar drying is one of the popular post-harvest methods that focuses on maintaining the nutritional value of tomatoes. The advantage of using this method is that it can operate in places with high temperatures like in Morogoro and Mvomero District Councils. The majority of tomato growers use the abundant solar heat available in their villages to preserve a greater proportion of tomatoes."

Another tomato grower from Matombo village reported that:

"Using the solar drying practice has enabled me to preserve more than 30 kilograms of tomatoes. Through this process, I can use the dried tomatoes during the rainy season when the produce is scarce at the market. This signifies that the respective method improves the nutritional status at the household level where family members reside."

Findings obtained from the respondents imply that the respective post-harvest method is so convenient to the ordinary tomato growers since its operational cost is extremely low. Farmers who apply this method have the opportunity to preserve their tomato produce at low costs. One of the extension officers who participated in the study confirmed that:

"Solar drying practices enhance the shelf life of tomatoes. Apart from the improvement of nutritional standards in diets, the respective practices minimize the shelf life of tomatoes. The dried tomatoes can be used by the farmer for 3 months (particularly during the rainy season when the supply size is lower than demand)."

All these respondents reported on the significant role of the respective post-harvest method towards reduction of PHL at the household level. They admit that tomato growers who apply this method are in a better position to access proper nutritional values of tomato produce and maximize profit through the local business networks with rural dwellers in the study area.

Further, the demand for dried tomatoes is very low. Therefore, tomato growers engage in such practices for sake of having sufficient amount of tomato produce in the store that can be used during the rainy season when the supply of the respective crop is extremely low. It is therefore important for the tomato growers to engage in such post-harvest practices because it reduces food losses and enhance food security for the responsible household members in the study area.

4.6 Perception of Tomato Growers towards the Indigenous Post-harvest Technologies

Findings summarized in Table 7 reveal that 80% of the respondents agreed to the statement that; indigenous post-harvest technologies suit the demand of local producers operating in the periphery, while 15% of them denied the statement. This implies that most of the growers are positively considering indigenous post-harvest handling practices, which is a manifestation of the desirable cultural heritages that our local communities possess. If the respective technologies are made out of local materials that are available and accessible in our communities, it is therefore true that the presence of such technologies represents the identity of our cultural values that emphasize on innovations and work as key components of human integrity.

Table 7: Perception of tomato growers towards the indigenous post-harvest technologies (N=100)

Statements	Disagree %	Neutral %	Agree %
Indigenous post-harvest technologies suit the demand of local producers operating in the periphery	15	5	80
Indigenous post-harvest technologies enable tomato growers to reduce the rate of PHL in the household	10	3	87
Indigenous post-harvest technologies enable tomato growers to protect the nutritional values of their produce	9	2	89
Indigenous post-harvest technologies enable tomato growers to maintain quality of their produce and access profitable markets that can guarantee higher returns	5	4	91
Indigenous post-harvest technologies enable tomato growers to rely on traditional and locally made materials	5	3	92
Indigenous post-harvest technologies are simple and affordable	4	3	93
Indigenous post-harvest technologies operate for the common good	3	3	94

NB: Numbers in the bracket represent percentages

Also, results from the field reveal that 87% of tomato growers affirmed that indigenous post-harvest technologies reduce the rate of PHL at the household level, while 10% denied the statement, and 3% of the respondents remained neutral. This signifies that tomato growers in Mvomero and Morogoro District Councils have practical experience on how such post-harvest handling technologies have helped them to increase financial stability through business being undertaken at the market as a result of the availability of quality tomato produce.

The findings depict that 89% of the respondents revealed that indigenous post-harvest technologies enable tomato growers to protect the nutritional value of their produce, while 9% had a negative response towards the respective statement. Generally, the respondents affirmed that proper use of such technologies does not destroy the nutrients of tomatoes, rather it protects them for the betterment of the consumers/users. The situation is different for their counterparts who use modern post-harvest technologies, which involve maximum utilization of chemicals that have negative effects on the nutritional value of horticultural produce. This shows the need of disseminating such technologies to the local farmers to help them protect the originality of their produce.

Notably, 91% of the tomato growers reported that indigenous post-harvest technologies play an imperative role in protecting the quality of tomato produce, while 5% of them denied the attitudinal statement. The respondents with positive response argued that proper use of such technologies maintains the caloric value, edibility and consumer acceptability of the products. This signifies the need of investing more in indigenous post-harvest technologies to protect horticultural produce whose demand is extremely high within and outside the country. According to Kader (2013), tomato growers who manage to maintain the quality of their produce can access profitable markets, maintain trusts consumers, and opens the opportunity for maximizing profit.

Moreover, findings in Table 7 report that 93% of indigenous post-harvest technologies are simple and affordable whereas 4% of them denied the statement, and 3% remained neutral. The majority of respondents accept that indigenous post-harvest technologies are not expensive compared to the modern ones because they are made by local technicians who use local materials as raw materials. The presence of expertise and raw materials reduces operational costs and, thus, reducing the price for procuring them.

4.7 Contribution of the Indigenous Technologies on Reducing Post Harvest Losses

4.7.1 Number of times for using local method

On understanding the contribution of IK on reducing PHL, the respondents were asked to compare the farming outputs before and after the use of the methods. When asked how often they have used local knowledge for post-harvest tomato handling, the results show that 50% rarely used, 40% very often and 10% did not use as shown on Table 8. The results show that most of the farmers are used to practicing IK. One of the key informants said, "*This has been part and parcel of any of our members of the tomato farmers because it is part of our cultural values and taboos. The practice has been undertaken for years because it is handed down as a tradition. Something which you*

may wonder is that most of the locally processed tomatoes are for domestic purposes not for selling. We usually sell to the market the tomatoes which are not defective."

Table 8: Number of time for using local methods

Time for Using Local Methods	No	%
None	10	10.0
Rarely	50	50.0
Very often	40	40.0
Total	**100**	**100.0**

Source: Survey, 2023

4.7.2 The extent of considering IKS for tomato handling

The farmers were inquired to state how useful is to consider IKS on tomato loss handling than other methods. It was seen that 40% of the farmers consider the method to be very useful, 41% don't know, 26% somehow useful and 3% rejected the method as shown in Table 9. The results indicate that most of the farmers consider the IKS to be useful because it is cheaper, accessible, reliable and cultural issue embedded in the participants. However, some respondents still doubt the usefulness of the method because it has not received much attention from outside the world compared to MKS.

Table 9: The extent of considering the local knowledge for tomato handling over other methods

Extent of considering more IKS than other methods	No	%
Don't Know	41	41.0
Not at all	3	3.0
Somehow useful	26	26.0
Very useful	40	40.0
Total	**100**	**100**

Source: Survey, 2023

4.9.3 Reasons for preferring IKS over MKS

The question was on establishing the reasons for the preference given to IKS over MKS. 50% of the respondents preferred local methods because of their ability to retain the original taste of the tomato even after the process. 20% because of their availability and accessibility, 20% cheap and 10% environmentally friendly as presented in Table 10. It was explained that processing tomato locally retains the original test than the refrigerated ones.

Table 10: The reasons for preferring IKS over MKS

Preferring more IKPHLT than Modern Method	No	%
Environmentally friendly	10	10.0
Cheap	20	20.0
Available and accessible	20	20.0
Retain the original taste	50	50.0
Total	**100**	**100.0**

Source: Survey, 2023

There were some discussions that local means gives shorter shelf life than modern ones. It was also noted that IKS is cheaper and easy to be operated by just simple lay farmers because it is part of the community identity. The question of environmentally friendly technologies was also credited to the side of the IKS since no carbon emission is involved, and less chemicals are used which opens a room for organic tomato.

4.10 Factors Affecting Adoption of the Indigenous Post-harvest Technologies among Tomato Growers

Findings in Table 11 reveal that income status of tomato growers is one of the leading factors affecting adoption of indigenous post-harvest technologies among tomato growers in the study area. This implies that farmers with high income have a greater chance of adopting the respective technologies compared to their counterparts with lower income. This situation prevails because income enables tomato growers to procure various local post-harvest technologies for the sake of preserving the nutritional value of their produce.

Table 11: Factors affecting adoption of indigenous post-harvest loss

Factors	No	%
Age of the tomato growers	15	15.0
Education status of the respondents	23	23.0
Perception of tomato growers towards IPT	18	18.0
Income Status of tomato growers	23	23.0
Access to Profitable Markets	21	21.0
Total	**100**	**100**

Source: Field Survey, 2023

Results in Table 11 reveal that the presence of profitable markets encourages tomato growers to adopt and use indigenous post-harvest technologies for protecting the quality of tomato produce. Notable, 21% of the respondents reported that the need to protect the nutritional value of tomato produce is driven by the presence of profitable markets that can ensure higher earnings for the producers and other participants involved in the value chain. This implies that post-harvest losses limit the capacity of tomato growers to satisfy the available markets and, thus, PHL reduces the possibility of making profit in the respective business.

In addition, findings in Table 11 depict that 23% of the tomato growers mentioned that education status can determine the level of adoption of the local post-harvest technologies. This signifies that the rate of adoption is higher for the educated tomato producers and lower for their counterparts without education. Similarly, Gonzalez (2019) reported that educated farmers adopt more local post-harvest technologies than their counterparts because they have the capacity to know the essence of such technologies and how they help them maintain the quality of tomato produce, which is a requirement for accessing available market opportunities for the betterment of all.

The findings reveal that 15% of the respondents mentioned age of the respondents as a factor affecting the adoption of indigenous post-harvest technologies in the study area. Through conversation with key informants, it became clear that aged tomato growers adopt more local post-harvest technologies compared to the young ones because the former have practical experiences on how such technologies are essential in enhancing productivity and reducing PHL.

Moreover, 18% of the respondents agreed that positive perception towards the indigenous post-harvest technologies can have a positive influence on the adoption of such practices. Such farmers adopt such technologies because they are sure of the possibility of reducing the rate of quantitative and qualitative PHL at the household level. Reduction of post-harvest losses opens a room for tomato growers to undertake profitable business with reliable customers.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents coherently conclusion of the obtained findings from the study and thereafter recommendations of interventions to various stakeholders operating in the government and in the private sector.

5.2 Conclusion

Tomato production is essential for improving nutrition for the consumers and raising income for the producers. However, the problem of PHL in tomato subsector limits the capacity of producers to increase productivity and, thus, experience the better livelihood standards in all perspectives. The need to use indigenous post-harvest technologies is driven by the difficulties in accessing modern post-harvest technologies, which are expensive, complex and environmentally destructive. In addition, the users of the indigenous post-harvest technologies intend to keep their identity that originated from the past generations.

During face-to-face interviews with tomato growers, the study confirmed that tomato growers who prefer indigenous post-harvest practices experience positive changes in their livelihood status. One of the changes include their capacity in maintaining the quality of their produce, which enables them to access profitable markets that could guarantee higher income for the producers.

Despite the achievements reported by the respondents in the study area, the study noticed that extension officers need to invest in capacity building to empower tomato growers to focus on supporting tomato growers to utilize indigenous post-harvest technologies in a more systematic way to enhance productivity for the common good. Such practices could enable farmers to have a sufficient stock of processed tomato that can be consumed during the rainy season when the level of productivity is extremely low.

Interventions from the extension officers is important to change their perceptions towards the indigenous post-harvest technologies. Instead of promoting the use of modern technologies, the responsible personnel have to be empowered to thoroughly undertake an evaluator of indigenous post-harvest technologies in tomato subsector and their importance in preserving the environment and preserving the health status of the consumers. The repercussions of adopting modern post-harvest technologies, which involves the use of chemicals should be discouraged to protect the wellbeing of consumers who are in danger of being infected with various forms of diseases.

The study has identified that indigenous post-harvest technologies are still needed by the farmers who produce vegetable and perishable agricultural items because they meet the needs of local producers who are always striving to reduce post-harvest losses in their farms and ultimately enhance productivity.

Finally, this study does not intend to discourage tomato growers from using desirable modern post-harvest technologies. But it shows the importance of harmonizing desirable modern with indigenous post-harvest practices that are environmentally friendly so that farmers could use them for reducing food losses and enhancing productivity.

5.3 Recommendations

Based on the foregoing conclusion, the study recommends the following:

a) The Agricultural Research Institutes have the duty to disseminate indigenous post-harvest technologies to the tomato growers basing on the nature of their localities as a means of resolving the problem of post-harvest loss. Such programmes should involve the Local Government Authorities, since they work closely with the people in the grass root communities, and they have agricultural officers who work directly with small scale farmers.

b) The Government has to re-launch the rural microfinance program in order to empower Savings and Credit Cooperative Societies and Village Community Banks which play imperative roles in providing financial services to the farmers in rural Tanzania (tomato growers inclusive). Accessibility to such financial services may enable tomato growers to procure/improve indigenous post-harvest technologies for maintaining the nutritional values of their produce.

c) The Local Government Authorities have to open a room for Non-Governmental Organizations to design and implement projects that rests on promoting the use of environmentally friendly post-harvest technologies that can protect the health status of consumers and ensure high productivity for the farmers (including tomato growers). This strategy should involve extension workers and other related professions for the sake of promoting organic farming in the country.

d) The Ministry of Agriculture, Food Security and Cooperatives should develop a comprehensive national plan to involve local experts who re-design/improve various indigenous post-harvest technologies as a strategy to reduce the rate of post-harvest losses and protecting the quality of horticultural products, which are highly consumed by people of different socio-economic status within and outside the country.

e) Elders possess sufficient knowledge and skills of the post-harvest handling practices in the tomato subsector and other related subsectors. It is the right time to involve them in agricultural programmes that focus on disseminating indigenous post-harvest technologies for the young farmers in the periphery where electricity and other energy services are not accessible.

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APPENDICES

Appendix A: Semi Structured Questionnaire for Tomato Growers

Basic Information

- District.....
- Ward.....
- Village.....

SECTION A: Socio -demographic characteristics

1. Respondents' age (yrs): .....
2. Respondents' Sex: (a) male (b) female
3. Household size (number of household members): .....
4. Respondents' educational level (yrs in schooling):.....
5. Head of the Household (a) male (b) female
6. Farmers' Experience (yrs in farming):.....
7. Land Size (acres):.....
8. Means of acquiring land: (a) inheritance (b) procuring (c) Government support.

SECTION B: An Overview of Tomato Production

9. Where do you engage in tomato production? .....
10. Are there different varieties of seeds do you use during production? (a) yes (b) no
11. If yes, what are they?.....
12. Who are the labours? .....
13. Where do you get them?.....
14. Where do you procure agricultural inputs?.....
15. Are they affordable/expensive? (a) yes (b) no
16. If yes, how? ....
17. How much do you produce per week?.....
18. Who is your consumer/buyer?.....
19. How do you relate with your consumers?.....
20. Are there changes of price over time? (a) yes (b) no.....
21. If yes, what are the reasons?.....
22. What challenges do you face when selling tomato produce?.....
23. How do you tackle them?.....
24. Rate of PHL (kgs):.....
25. How does the post-harvest loss affect your wellbeing?.....

SECTION C: Indigenous post-harvest technologies in the tomato subsector

1. Do you have indigenous post-harvest technologies for reducing PHL in the tomato subsector? (a) yes (b) no
2. If yes, what kinds of indigenous post-harvest technologies do you have?.....
3. Which one is the most suitable IPT?.....
4. How do these technologies support you in reducing PHL in tomato subsector?.....
5. What challenges do you face when using these local post-harvest technologies?.....

SECTION D: Perception of Tomato Growers towards the Indigenous Post-harvest Technologies

Statements	Disagree	Neutral	Agree
Indigenous post-harvest technologies suit the demand of local producers operating in the periphery			

Indigenous post-harvest technologies enable tomato growers to reduce the rate of PHLes in the household			
Indigenous post-harvest technologies enable tomato growers to protect the nutritional values of their produce			
Indigenous post-harvest technologies enable tomato growers to maintain quality of their produce and access profitable markets that can guarantee higher returns			
Indigenous post-harvest technologies enable tomato growers to rely on traditional and locally made materials			
Indigenous post-harvest technologies are simple and affordable			
Indigenous post-harvest technologies operate for the common good			

SECTION D: Effectiveness of Post-harvest Technologies in the Tomato Subsector

5. How often have you used local knowledge for tomato handling?
    a) None
    b) Rarely
    c) Very often
6. To what extent do you consider IKS than other methods?
a) Don't know
b) Not at all
c) Somehow useful
d) Useful
7. What are the reasons for supporting IKS more than MKS?
a) Environmentally friendly
b) Cheap
c) Available and Access
d) Retain the original taste
8. What are the factors affecting adoption of the indigenous post-harvest technologies in tomato produce?.....

Appendix B: Key informants Interview for Extension Workers

1. What is your main role in supporting the development of tomato subsector?
2. How do you evaluate the performance of tomato production?

3. How is the problem of post-harvest losses in tomato produce?
4. How does the problem of PHLes affect the wellbeing of tomato growers?
5. How do you assist tomato growers to tackle the problem of PHLes?
6. Do you have indigenous post-harvest technologies for reducing PHLes in your area?
7. What measures have you taken to encourage tomato growers to adopt local post-harvest technologies?
8. What is the response from the tomato growers regarding adoption of indigenous post-harvest technologies?
9. Do you get any support from the respective local government in promoting the use of IPT? If yes, how?.....

Appendix B: Key informants Interview for a SIDO technician

1. What is your main role as SIDO technician?
2. Do you have sufficient information on PHLes prevailing in the tomato subsector (Mvomero and Morogoro DC)?
3. If yes, how is the problem affects the well-being of tomato growers?
4. Do you have time to work with ordinary tomato growers through introducing new machines?
5. Do you assist them in adopting indigenous post-harvest technologies?
6. If yes, how.....?
7. What can be done to resolve the problem of PHLes in tomato subsector?

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