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POSTHARVEST LOSSES OF FRESH TOMATO PRODUCTION IN CAMERON HIGHLANDS AND LOJING HIGHLANDS, MALAYSIA

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By

LEE KWEE TIONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2020

DEDICATION

This thesis is dedicated to

My wife, my kids, and my lovely grandchildren

With love, respect, and a bunch of memories

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

POSTHARVEST LOSSES OF FRESH TOMATO PRODUCTION IN CAMERON HIGHLANDS AND LOJING HIGHLANDS, MALAYSIA

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May 2020

Chairman : Associate Professor Ismail Abd Latif, PhD
Faculty : Agriculture

In Malaysia, postharvest losses of vegetables are estimated to be about 20-50%. Tomato is the most important high-value vegetable crops with enormous potential for export in Malaysia. But quantitative evidence of postharvest losses of tomato is limited due to less attention has been given to the study on postharvest losses. To the best knowledge of the author, there is no research study on postharvest losses of tomato in Cameron Highlands and Lojing Highlands using the approach of estimating the losses at the identified critical loss points of each of the key players along the agrifood supply chain. The goal of this study was to extend the effort made by previous authors by estimating the postharvest losses of fresh tomato production using a different approach, sampling method instead of tracking or direct measurement. As the problem of high postharvest losses that usually occur on the farm in developing countries and farmers' income was affected the most. It is, therefore, necessary to conduct a study on determining factors influencing postharvest losses of tomato at the farm level. As the adoption of postharvest practices is found to be negatively correlated to postharvest losses, it is, therefore, necessary to conduct a study on determining determinants influencing farmers' adoption on postharvest practices. Thus, the main objective of this study is to estimate the postharvest losses of fresh tomato production in Cameron Highlands and Lojing Highlands.

A combination of multistage random sampling technique and snowball sampling techniques were used to select tomato farmers and key players at various stages of the tomato supply chain. Data were collected through personal interviews using a structured questionnaire from 133 respondents which included 110 farmers, 11 collectors, 4 wholesalers, and 8 retailers. Descriptive analysis was used to summarize the socio-economic and demographic profiles of the respondents and the estimation of postharvest losses of tomato. Factor analysis

and multiple linear regression analysis were used to determine the factors influencing the postharvest losses of tomato at the primary production level. Chi-square analysis was used to determine the association between farmers' adoption of postharvest practices and socio-economic and demographic profiles. Logistic regression analysis was used to determine determinants affecting farmers' decisions on the adoption of postharvest practices.

The findings revealed that estimated postharvest losses at the farm, collector, wholesale markets, and retail levels were 5.43%, 2.79%, 0%, and 11.51 %, respectively. The results of multiple regression analysis suggested that skilled harvesters and the adoption of postharvest practices were the two factors found to have an inverse relationship with postharvest losses of fresh tomato at the farm level. On the other hand, harvesting methods, storage, and poor processing and packaging were the three factors found to be positively related to postharvest losses of fresh tomato at the farm level and these results confirmed the hypotheses of this study. The results of Chi-square analysis revealed that farmers' age, experience, and awareness level were significantly associated with farmers' adoption of postharvest practices. Concerning determinants that influence farmers' decision on the adoption of postharvest practices, the results from logistic regression analysis indicated that farming experience, awareness-knowledge of postharvest practices, and perceptions of postharvest practices were found statistically significant with farmers' decision on adoption of postharvest practices.

The policymakers should find ways to improve farmers' knowledge on postharvest practices as well as to improve their perceptions about the benefits of postharvest practices towards reducing postharvest losses. Hence, more farmers will adopt the postharvest practices as recommended by the policymakers. This study adds to the body of knowledge of postharvest losses along the food supply chain literature by increasing understanding of postharvest losses problems, particularly the tomato supply chain in Malaysia. Effective measures and interventions can be developed based on the identified factors and causes influencing postharvest losses. Thus, the reduction of postharvest losses can be achieved, and the business performance of farmers can be improved.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KERUGIAN PASCA TUAI PENGELUARAN TOMATO SEGAR DI CAMERON HIGHLANDS DAN LOJING HIGHLANDS, MALAYSIA

Oleh

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Di Malaysia, kerugian pasca tuai sayur-sayuran dianggarkan sekitar 20-50%. Tomato adalah tanaman sayuran bernilai tinggi yang paling penting dengan potensi besar untuk dieksport. Tetapi bukti kuantitatif kerugian pasca tuai tomato adalah terhad kerana kurang perhatian diberikan kepada masalah tersebut. Setahu penulis, tidak ada kajian penyelidikan mengenai kerugian pasca tuai tomato di Cameron Highlands dan Lojing Highlands yang menggunakan pendekatan menganggarkan kerugian pada titik kerugian kritikal yang dikenal pasti setiap peniaga penting di sepanjang rantaian bekalan makanan pertanian. Tujuan kajian ini adalah untuk memperluaskan usaha yang dilakukan oleh penulis sebelumnya dengan menganggarkan kerugian pasca tuai tomato segar dengan menggunakan pendekatan yang berbeza iaitu kaedah persampelan dan bukannya pengesanan atau pengukuran langsung. Oleh kerana masalah kerugian pasca tuai yang tinggi yang biasanya berlaku di peringkat ladang di negara-negara membangun dan pendapatan petani sangat terjejas. Kajian untuk menentukan faktor-faktor yang mempengaruhi kerugian pasca tuai tomato di peringkat ladang perlu dijalankan. Adalah didapati aplikasi amalan pasca tuai berkorelasi negatif dengan kerugian pasca tuai, kajian untuk menentukan faktor-faktor yang mempengaruhi pekebun tomato terhadap aplikasi amalan pasca tuai perlu dilakukan. Objektif utama kajian ini adalah untuk menganggarkan kerugian pasca tuai tomato segar di Cameron Highlands dan Lojing Highlands.

Teknik kombinasi pensampelan rawak pelbagai peringkat dan teknik pensampelan bola salji digunakan untuk memilih responden penanam tomato dan peniaga utama di pelbagai peringkat rantaian bekalan tomato. Data dikumpul melalui temubual peribadi menggunakan soal selidik berstruktur daripada 133 responden yang terdiri daripada 110 pekebun tomato, 11 pengumpul sayur-sayuran, 4 peniaga pasar borong dan 8 peniaga runcit. Analisis deskriptif digunakan untuk merumuskan profil sosioekonomi dan

demografi responden dan anggaran kerugian pasca tuai tomato. Analisis khi-kuasa dua digunakan untuk menentukan kaitan antara pelaksanaan amalan pasca tuai dengan profil sosioekonomi dan demografi responden. Analisis faktor dan analisis regresi berganda linear digunakan untuk menentukan faktor-factor yang mempengaruhi kerugian pasca tuai tomato di peringkat ladang. Analisis regresi logistik digunakan untuk menetukan faktor-faktor yang mempengaruhi responden terhadap aplikasi amalan pasca tuai.

Hasil kajian mendapati kerugian pasca tuai di peringkat ladang, pengumpul sayur-sayuran, pasar borong dan peniaga runcit masing-masing adalah 5.43%, 2.79%, 0% dan 11.51%. Keputusan analisis regresi berganda menunjukkan bahawa kemahiran penuai dan pelaksanaan amalan pasca tuai didapati memberi kesan mengurangkan kerugian pasca tuai tomato segar di peringkat ladang. Disebaliknya, kaedah penuaian, penyimpanan, dan pemprosesan dan pembungkusan yang kurang baik merupakan faktor-faktor yang menyumbangkan kepada kerugian pasca tuai tomato segar di peringkat ladang dan keputusan ini menyokong hipotesis kajian ini. Hasil analisa khi-kuasa dua menunjukkan bahawa umur, pengalaman dan tahap kesedaran pengetahuan para petani berkait rapat dengan pelaksanaan amalan pasca tuai. Berkenaan dengan faktor penentu yang mempengaruhi petani terhadap pengamalan amalan pasca tuai, hasil dari analisis regresi logistik menunjukkan bahawa pengalaman, pengetahuan serta kesedaran tentang amalan pasca tuai dan persepsi terhadap amalan pasca tuai didapati signifikan secara statistik dengan petani yang mengamalkan amalan pasca tuai dengan tujuan mengurangan kerugian pasca tuai.

Penggubal dasar harus mencari jalan untuk meningkatkan pengetahuan petani mengenai amalan pasca tuai dan juga meningkatkan persepsi mereka mengenai faedah amalan pasca tuai terhadap kerugian pasca tuai. Dengan itu, lebih ramai petani akan mengamalkan amalan pasca tuai sepertimana yang disarankan. Kajian ini dapat menambahkan kepada pengetahuan tentang kerugian pasca tuai sepanjang rantaian bekalan makanan dengan meningkatkan pemahaman tentang masalah kerugian pasca tuai, khususnya rantaian bekalan tomato segar di Malaysia. Langkah-langkah dan intervensi yang berkesan dapat ditentukan berdasarkan faktor-faktor yang mempengaruhi kerugian pasca tuai yang telah dikenalpasti. Oleh itu, pengurangan kerugian pasca tuai dapat dicapai, dan seterusnya prestasi perniagaan pekebun tomato dapat ditingkatkan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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This is to confirm that:

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AFSC	Agrifood Supply Chain
BOT	Balance of Trade
CHVGA	Cameron Highlands Vegetable Grower Association
AVA	Agrifood and Veterinary Authority of Singapore
CLPs	Critical Loss Points
DV	Dependent Variable
DOA	Deprtment of Agriculture
DOSM	Department of Statistics Malaysia
EFA	Exploratory Factor Analysis
EPU	Economic Planing Unit
FAMA	Federal Agricultural Marketing Authority
FAO	The Food and Agriculture Organization of the United Nations
FLW	Food Losses And Waste
FSC	Food Supply Chain
GDP	Gross Domestic Product
HLPE	The High Level Panel Of Experts On Food Security And Nutrition
IV	Independent Variable
KMO	Keiser-Meyer-Olkin
LVGA	Lojing Vegetable Grower Association
MARDI	Malaysian Agricultural Research and Development Institute
MLR	Multiple Linear Regression
OA	Ministry of Agriculture and Agro-based Industry

MRL	Maximum Residue Limit
MNC	Multinational Corporation
PHLs	Postharvest Losses
SC	Supply Chain
SCM	Supply Chain Management
VIF	Variance Inflation Factor
WEF	World Economic Forum
WFLO	World Food Logistics Organization
WMO	World Meteorological Organization
WRAP	Waste And Resources Action Programme
WRI	World Resources Institute

CHAPTER 1

INTRODUCTION

This chapter aims to introduce the study undertaken in this thesis. This chapter begins with a description of the background of the study. Furthermore, an overview of the tomato production, current practices, tomato supply chain, current marketing, and key activities of the study are discussed. The issue of postharvest losses and factors contributing to postharvest losses are also discussed. Then, it proceeds with a discussion on the problem statement and research gaps. The general research objectives and the specific objectives of this research are presented. The significance of the study, scope, and limitations of the study are also presented in this chapter. The chapter concludes with the organization of the thesis.

1.1 Background of the Study

To ensure the availability of food to meet the demand of the world rapid growing population that is projected to reach 9.7 billion people by 2050 (UN, 2015), the annual global food production will need to be 60% more than it was in 2006 (Kitinoja, Saran, Roy & Kader, 2011; Lipper, McCarthy, Zilberman, Asfaw & Branca, 2015). This can be a very daunting task especially when the world is not only facing the climate change, the world is also facing the challenge of sustainable use of limited natural resources such as limited fertile land, decreasing water for agriculture and increasing energy cost (Adeoye, Odeleye, Babalola & Afolayan, 2009; Lipper *et al*., 2015). The international community has been recognized that climate change can have significant negative impacts on food production and food security (Frank, Witzke, Zimmermann, Havlík & Ciaian, 2014; Iglesias & Quiroga, 2011; Lipper *et al*., 2015). Food losses and food waste (FLW) are perennial issues worldwide and widely acknowledged as one of the main contributors to food insecurity. It is a sad realization that about one-third of the food produced globally which is equivalent to about 670 million metric tonnes of food suitable for human consumption is thrown away in high-income countries each year and 630 million metric tonnes in low- and middle-income countries, a total of 1.3 billion metric tonnes whether intentionally or unintentionally by both consumers and food supply chain (FSC) players, affecting not only our economy, our well-being but also our lovely environment (Gustavsson *et al*., 2011). The full economic costs on global FLW are substantial and amount to about USD 1 trillion a year (FAO, 2014). Food losses and waste has significant negative economic impacts for farmers and other key players along the FSC and translate into higher food price for consumers (FAO, 2017).

Postharvest losses (PHLs) refer to the measurable quantitative and qualitative agrifood losses that occur along the FSC from the time of harvest to processing, transportation, and marketing, to the final consumption by the consumer (de Luciaand Assennato, 1994; Parfitt *et al*., 2010; Kitinoja *et al*., 2011; Kiaya, 2014;

Emana *et al*., 2017). Postharvest losses may reduce food availability in the market, which may cause food prices to increase (Liu & Rezaei, 2017). Reducing PHLs along the FSC is therefore increasingly getting concerned and attention of the world and can be a complementary solution to increase the food availability to ensuring future global food security (Aulakh & Regmi, 2013; Kummu *et al*., 2012; Parfitt *et al*., 2011; FAO, 2009). Reduction of PHLs can also be easing the challenges of limited natural resources where less land, less water, and less energy needed for food production (Kader, 2003). Postharvest losses of horticultural crops are significant and very common in low-income countries. Highly perishable fruit and vegetables undergo the greatest proportion of PHLs in low-income countries; almost half of all fruits and vegetables produced are lost and wasted along the FSC (Parfitt *et al*., 2011). In Malaysia, postharvest losses of vegetables are estimated to be about 20-50% (Aini, Sivapragasam, Vimala, & Mohamad Roff, 2005). Postharvest losses occur throughout the FSC, at any postharvest activities such as harvesting, sorting and grading, packaging, storage, transportation, and sales and marketing (FAO, 2011). Postharvest losses are a major issue in tomato supply chains, particularly in the hot and humid tropical climates, as high as 40% of harvested fruits are loss and waste along the supply chain (Macheka *et al.,* 2018). A study carried by Humam et al. (2011) on five tomato farms in Cameron Highlands reported PHLs of tomato from farm to retailer were 25.7%.

Tomato (*Solanum lycopersicum*) is one of the most important and extensively consumed vegetable crops in the world with an estimated world production of 146 million tons (Monte *et al*., 2013). Indeed, it is also a major and important vegetable crop in terms of popularity and market value in Malaysia. Tomato is a highly perishable vegetable and reported to have high postharvest losses mainly due to mechanical injuries and physiological disorders (Humam *et al.*, 2011), which brings substantial loss to the farmers and other key players along the agrifood supply chain, hence to the national economy. The market value of tomato has increased from RM 64 million in 2009 to almost RM 1.9 billion in 2018 based on wholesale price. In general, tomato production continues to indicate strong growth. Tomato production in Malaysia is mainly cultivated in highlands and concentrated in Cameron Highlands, Pahang (62.11%), Lojing Highlands, Kelantan (35.0%), and other areas include Kinta, Perak (2.15%) and Kundasang, Sabah (0.74%) based on production in 2018 (MOA, 2019). Under the Economic Transformation Program (ETP), the Entry Point Project 7 (EPP 7) for Agriculture Sector, National Key Economic Area (NKEA), tomato together with lettuce and capsicum have been identified as the three high-value highlands vegetable crops with enormous potential for export (MOA, 2010).

Tomatoes are consumed either sliced fresh in salads, sandwiches, or use in their recipes as the flavorful main ingredient for sauces, soups, meat or fish dishes, and vegetarian dishes (Kojo *et al*., 2015). Besides tasting delicious, tomatoes also are an excellent source of vitamins, minerals, and dietary fibers which play a very significant role in a well-balanced diet (Adeoye *et al.,* 2009; Kader, 2013). Lycopene, an oxygenated carotenoid pigment with great antioxidant properties in tomatoes are associated with lowering the risk of cancer and cardiovascular-related diseases (Riccioni *et al*., 2008).

1.2 Tomato Production in Malaysia

Vegetables can be classified based on edible parts of the plant such as leaves, stem, fruits, pods, flowers, roots, bulbs, tubers, and seeds (Major, 2017). Table 1.1 shows the planted area of tomato is the lowest among other vegetables, but it has increased almost double from 1,451 ha in 2011 to 2,831 ha, reaching the peak in 2013 due to the high ex-farm price of RM 4.50 per Kg in 2013 (The Sun Daily, 2014). The high price attracted hundreds of farmers rush to switch to plant tomato and results over-production of tomato in early 2014, causing the price to reach rock bottom at RM 0.20- 0.30 per Kg. The high fluctuation in the tomato price was a big loss to the farmers and because of this incidence, the tomato planted area had reduced and remained at a lower figure of around 2000 hectares from 2014 and 2019. Generally, the crop cycle for tomato is 180 to 240 days per cycle, farmers are easily switching whether to plant a tomato or not based on the market price of tomato. Therefore, the planted area of tomato also fluctuates every year. In terms of production, tomato is the most important vegetable among the local vegetables from 2016 to 2019 (Table 1.2). In general, tomato production continues to indicate steady growth. In 2018, the production was 199,422 metric tonnes and amounted to RM 558.34 million in terms of value based on ex-farm price (Table 1.3). About 70% of the production is consumed locally, while 25% is exported to Singapore and 5% to countries, such as United Arab Emirates, Hong Kong, and the Maldives (Chai, 2017).

Table 1.1: Planted Area of Selected Vegetables, 2011-2019

Crop	Planted Area (Hectares)								
	2011	2012	2013	2014	2015	2016	2017	2018	2019[e]
Spinach	4,098	4,023	4,288	4,386	3,947	4,411	5,732	5,891	6,421
Kangkong	6,015	3,832	3,776	3,962	4,019	4,228	5,040	4,409	4,629
Cabbage	5,655	3,528	4,845	7,937	8,720	4,045	3,418	3,502	3,677
Lettuce	2,460	2,069	3,346	3,127	3,195	3,072	2,552	2,892	3,325
Mustard	9,172	10,495	14,579	15,997	13,493	14,443	12,088	9,443	10,340
Tomato	1,451	1,978	2,831	1,948	2,000	2,823	2,001	2,192	2,367
Chilli	2,597	2,856	4,104	3,582	3,104	3,381	3,067	2,556	2,664
Long Bean	3,663	3,629	3,622	3,918	4,799	4,528	5,028	4,409	4,629
Brinjal	1,783	1,723	2,174	2,429	2,399	2,640	2,579	2,407	2,527
Cucumber	3,969	4,607	5,161	4,661	4,738	4,641	4,778	4,422	4,732

[Source: MOA (2016; 2017; 2018), DOA (2019)]

Table 1.2: Production of Selected Vegetables, 2014-2019

Crop	Production (metric tonnes)					
	2014	2015	2016	2017	2018	2019[e]
Spinach	51,286	48,357	54,823	71,180	72,308	75,960
Kangkong	41,395	45,287	45,042	58,880	57,140	60,508
Cabbage	301,318	277,202	101,258	77,342	80,641	83,600
Lettuce	67,320	66,006	65,268	40,358	46,114	51,647
Mustard	275,732	216,353	224,126	142,764	128,742	133,540
Tomato	162,384	165,177	242,946	188,185	199,422	205,550
Chilli	40,521	47,015	43,738	27,358	24,428	26,354
Long Bean	53,549	69,295	63,473	58,808	57,104	60,508
Brinjal	48,702	50,224	46,557	40,418	39,311	41,754
Cucumber	97,331	100,817	97,621	88,492	85,134	93,310

[Source: MOA (2016; 2017; 2018), DOA (2019)]

Table1.3: Sales Value of Selected Vegetables, 2014-2018

Crop	Sales Value[1] (RM '000)				
	2014	2015	2016	2017	2018
Spinach	69,237	71,729	93,200	121,006	110,269
Kangkong	55,884	63,401	63,058	75,555	71,509
Cabbage	331,670	401,943	182,265	100,545	120,962
Lettuce	179,744	240,922	212,121	137,218	125,660
Mustard	603,854	499,776	542,385	371,188	328,293
Tomato	341,006	359,259	425,156	338,734	558,383
Chilli	213,139	281,307	327,598	188,773	158,377
Long Bean	155,292	162,843	222,155	176,424	154,180
Brinjal	109,579	135,604	111,718	103,065	106,141
Cucumber	102,198	115,939	159,122	159,286	106,418

Note: [1] Based on ex-farm price
[Source: MOA (2016; 2017; 2019), DOA (2019)]

Table 1.4 shows the average yield of tomato total about 94.9 metric tonnes per hectare in 2018, increased by about 40% against the average yield five years ago. The average yield attained its peak level in 2017 to 97.0 metric tonnes per hectare. In 2019, Malaysia exported a total of 43,804 metric tonnes of tomatoes, remaining stable as compared to the previous year. However, the export figure in 2019 was decreased by 14.3% against 2016. Singapore was the main destination for tomato export from Malaysia, followed by the United Arab Emirates. Nevertheless, tomato also imported into Malaysia,

about 1,806 metric tonnes were imported in 2019, decreased by 61.1% against the previous year. Tomato has recorded a self-sufficiency ratio (SSR) of more than 100% and per capita consumption (PCC) of 5.4 Kg per year in 2016 (DOSM, 2017). Tomato is also the most frequently consumed fruits vegetable among Malaysian adults after cucumber (Othman, Karim, Karim, Adzhan & Halim, 2013).

Table 1.4: Production, Yield, Exports, Imports, Per Capita Consumption and Self-sufficiency Ratio of Tomato, 2015-2019

Item	2015	2016	2017	2018	2019[e]
Production (mt)	165,177	242,946	188,185	199,422	205,550
Yield (mt/ha)	83.2	86.9	97.0	94.9	86.8
Imports (mt)	5,988	2,577	3,618	4,646	1,806
Exports (mt)	43,838	51,110	47,165	44,445	43,804
PCC (kg/person/year)	3.5	5.4	3.9	4.2	NA
SSR (%)	131.8	125.0	130.1	126.5	NA

[Source: DOSM (2017; 2018; 2019; 2020), DOA (2019)]

Tomato production is mainly concentrated in Highlands such as Cameron Highlands (1,214 Ha), Lojing Highlands (692 Ha), and Kinta (152 Ha), about 1,000 meters above sea level (DOA, 2019). The good climate conditions and the year-round cool temperature in the highlands have greatly contributed to the production of temperate vegetables both for local and export markets. Tomato is currently the most important vegetable crop in Cameron Highlands and Lojing Highlands. It is cultivated all over the district with heavily concentrated in the northern region of Cameron Highlands and Lojing Highlands. Given the changing scenario that encourages more private investment, most farmers in Cameron Highlands and Lojing Highlands have gone for hi-tech horticulture with micro-propagation, protected cultivation under greenhouses or rain-shelter structures, drip irrigation, fertigation, and integrated nutrient and pest management, besides making use of latest post-harvest measures particularly in the case of perishable fruit and vegetables such as tomato. With the favorable weather condition and the year-round cool temperature, Cameron Highlands and Lojing Highlands areas are contributing to the production of superior quality tomatoes throughout the year.

1.2.1 Current Practices in Tomato Production

Tomato production in Cameron Highlands and Lojing Highlands requires high cost and labor-intensive attempts to produce high-quality fruit. Tomato can be grown in open fields or under protected cultivation. Most tomato farmers have shifted their farming technique from conventional open filed planting to a more environmental sustainability and high-yielding farming practices, greenhouse, or rain-shelter production supported with drip irrigation, fertigation, integrated

nutrient, and pest and disease control management. With the favorable climate conditions in the highlands, tomato can be grown all year round. The duration for one cycle of tomato production is about 5-8 months. The growth stage of tomato is not long and can be harvested in about 60 days after transplanting and the harvesting period lasts for about 3-6 months. On average, farmers can expect to have 25,000-26,000 plants (2 plants/polybag) in one hectare under the rain-shelter structures. Most farmers use coco-peat as the planting media. The average yield of tomato under the rain-shelter planting is around 4-5 Kg per plant depends on the farmers' experiences and their management. The average yield reported in 2018 was 97 metric tonnes per hectare (DOA, 2019). The common and popular tomato varieties grown in Cameron Highlands and Lojing Highlands are F1 hybrid Var Syngenta 1039 and F1 hybrid 344. The fruits are mainly flat-round, firm with excellent shelf-life.

Accompanied by Agriculture Officers and Officer from FAMA, the author of this thesis was able to visit a few of the production sites and obtain an overview of all the current farming practices, varieties grown, and preharvest factors that may influence on PHLs. As reported by Mohammed and Craig (2018), one of the critical loss points of tomato production was at harvest where the losses were considered to be highest. Therefore, to avoid high PHLs at harvest, the tomato should be harvested at the proper stage of maturity, the fruits should be harvested from the tree with care and the time of harvesting are important considerations during harvesting (Esguerra and Rolle, 2018). Tomatoes were mostly harvested by the workers in the morning, during the coolest time of the day and some were in the evening depending on the commitments of farmers with the transporters. Most farmers harvest the fruits by hand and fruits were harvested at the mature green stage (Index 2- shiny, light green surface) or partially ripe at index 3 (break color, orange-red covering almost 50% surface). Tomato quality at harvest is primarily based on uniform shape and size, free from pest and disease attack, and free from handling defects. Several farmers opted for preliminary field sorting to remove decayed or defect fruits from the plants during the harvesting process. Harvested tomatoes were placed into picking containers such as pails or plastics crates. Each crate holds about 10-20 Kg of fruits. Even though the harvesting containers or the crates were supposed to clean and sanitize at the end of every harvest day to remove soil and field debris to avoid contamination, but most farmers did not clean it the containers after every harvest day. Once the harvesting is completed, fruits were transported from the field to the packinghouse often adjoining the house or centralized packinghouse outside the farm. Most farmers owned a unit of small processing machines to sort and grade the fruits. Sorting to remove mechanical injuries and unmarketable fruits are carried out based on visual observation and grading by size based on diameter. Washing is seldom practiced by the small-scale farmers and the water quality is also questionable. The commercial or large-scale farmers process their fruits using high-technology sorting, grading, and packaging machines which start with washing, sorting by size based on weight, by color index, and packed into 10-Kg carton boxes. Fruits with mechanical damage such as cuts, punctures, bruises and scars, and unmarketable fruit such as immature green and red over-ripe fruits, off size fruits, and physical aesthetic defect fruits were removed before packing into the carton boxes.

1.2.2 Tomato Supply Chain

The fruits and vegetables move from the farm to the consumers through several marketing channels. The distribution chain for vegetables in Malaysia is primarily dominated by wholesalers where they play a significant role in the marketing of vegetable products (Man, Nawi, & Ismail, 2009). Consequently, small-scale farmers mainly rely on collectors/wholesalers in the marketing of their produce. Almost 63.6% of the farmers sold their vegetables to the wholesalers direct or indirectly (Man, *et al*., 2009). Fresh fruits and vegetable retailers in Malaysia mainly consist of supermarkets/Hypermarkets and the traditional wet market (Zakaria and Rahim, 2014). The traditional wet market retailers generally depend on the wholesalers for the supply of vegetables whereas the retail chains such as hypermarket/supermarket that require more secure, better quality produce, bigger volume and consistent supply normally get their supply direct from commercial farmers or the intermediaries instead of direct from the small-scale farmers because the production volume from a single farmer is insufficient or large enough to fulfill their demand volume.

Agricultural marketing in Malaysia is experiencing a great transformation in response to the increase of disposable income and the purchasing power of consumers. Rapid industrialization, great urbanization, more than 60% of Malaysia's populations live in the urban areas with a greater awareness of food safety, food quality, and more health-conscious hence began to demand higher quality and safe fruits and vegetables at reasonable prices (Arshad, Mohamed, & Latif, 2006; Arshad, 2010). The increase of per capita income levels of households is influencing the major changes in food demand patterns where the consumers tend to demand better quality food (Regmi*, et al*., 2001).

The tomato supply chain (Figure 1.1) involves tomato farmers, collectors/ transporters, wholesalers, retailers, and customers. It can be noticed that the first level of the supply chain is farmers where the physical product is harvested and travel all the ways until it gets to the consumer. Generally, the small-scale farmers in Cameron Highlands and Lojing Highlands depend on collectors/transporters or wholesalers for the marketing of their tomatoes as most of them do not have direct relations with the retail chains such as TESCO, Giants, AEON, and Aeon Big. Most of the small farmers are not able to meet the stringent product specification and strict quality requirements imposed by the retail chains. Some of the farmers do not have logistics facilities to deliver their tomatoes directly to the customers. Therefore, the transporters played a significant role in the SC of tomatoes in Cameron Highlands and Lojing Highlands. Some of the transporters act as collectors and play the role of intermediaries between the farmers and the wholesalers. Although FAMA also plays the role of a collector and has provided support to the small-scale farmers, most farmers still prefer to deal with the local collectors, transporters, and wholesalers for better price and FAMA has been known as the buyer of last resort particularly during glut market.

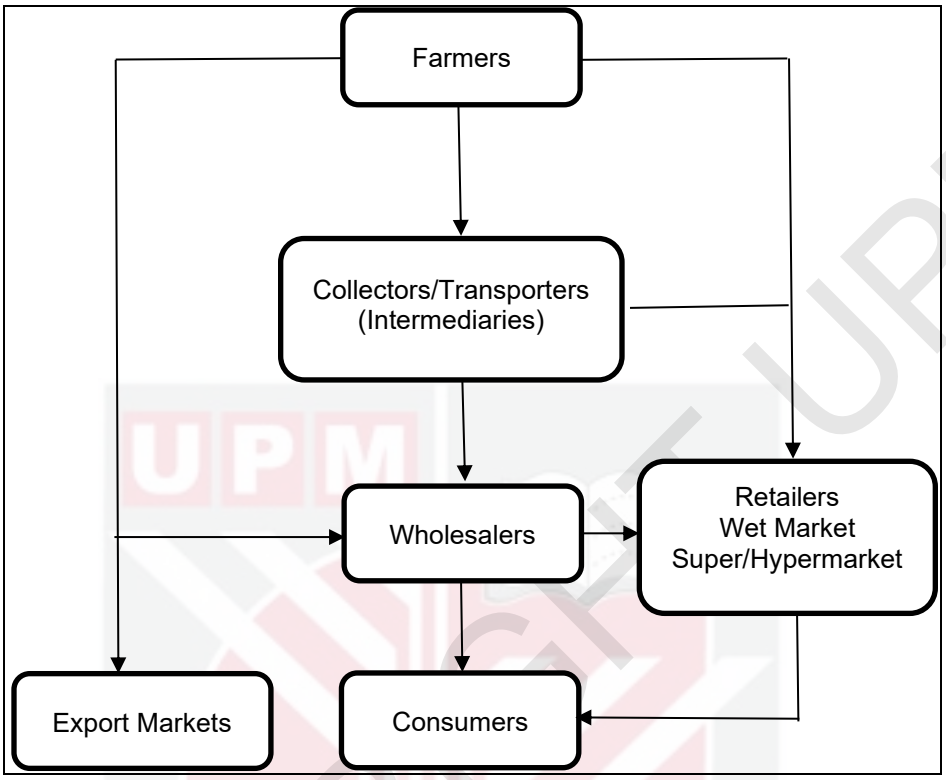

Figure 1.1: Tomato Supply Chain in Malaysia
[Source: By the author after getting information from FAMA and DOA (2019)]

With about 70% of the fresh fruits and vegetables are being purchased through hypermarkets/supermarkets (Abdullah *et al.,* 2011), tomato farmers could either group together and/or sell their produce direct to or through the intermediaries such as collectors or wholesalers who also act as processors who then consolidate and packing, then sell it to the retail chain stores. The procurement practices of retail chain stores are normally emphasized on quality and safety standards, big volume but require consistent supply, competitive pricing, value-added such as packing and packaging, and relatively longer payment terms which have big challenges for the small farmers to fulfill. Some of the large-scale farmers are also acting as collectors buying tomatoes from the small-scale farmers, then consolidate, sort, grade and package the tomatoes at their consolidation, processing, and packaging center. They deliver the products using their own ambient or cold trucks to the buyer or export their tomatoes using refrigerated containers to their oversea buyers. In other words, the supply chain of these farmers is shorter as compared to those who sell through transporters, then to wholesalers.

About 25% of the tomato productions are exported to Singapore and 5% to countries such as the United Arab Emirates, Hong Kong, and the Maldives (Chai, 2017). Tomatoes exported to Singapore will be delivered using cold trucks. Whereas tomato exported to other countries will be shipped by using refrigerated containers and this normally happened from April to December when there is a shortage of tomato in these countries.

1.2.3 Current Marketing System and Key Activities of the Study

Discussions with farmers, the secretary of Cameron Highlands Vegetable Grower Association, the secretary of Lojing Vegetable Grower Association, officers from FAMA Brinchang, MARDI Tanah Rata, DOA Brinchang and TKPM Lojing and empirical evidence suggest that the demand for fresh tomatoes is strong throughout the year, particularly after the expansion of the export market to the United Arab Emirates. There is general agreement that the wholesalers and the supermarkets/hypermarkets are the largest buyers, but the collections or distribution of tomatoes is still in the hands of collectors or transporters who act as intermediaries, and there is normally no true storage other than intermediaries just holding the tomatoes bought from the farmers for an average of 1-2 days. Small-scale farmers were mostly not organized when it came to the marketing of their products. They were engaged in individual production, looks for the buyer and therefore most of them had no group bargaining power. The intermediaries play an important role in the distribution of tomatoes to wholesale markets, supermarkets/hyper- markets, and export markets after buying directly at the farm-gate.

Figure 1.2 shows the flow of the tomato supply chain after inserting the stages of the postharvest handling practices for tomato within the SC from the point of harvest to consumption. According to Mohammed and Craig (2018), the three critical loss points where losses were considered to be highest, were at harvest, the packinghouse, and the display at retail marketing. The potential Critical Loss Points (CLP) for this study were identified. The harvesting stage served as the first CLP, sorting, and grading at farmer's packing house as second CLP, temporary storage, transportation, and selling were other CLPs at the farm level. Sorting and grading and transportation were the CLPs at the collector level. At the wholesale markets and retailers or the supermarket/hypermarket levels, the potential CLPs identified were at transportation, display, and selling stage, sorting and grading, and storage stages. According to Mohammed and Craig (2018), the three critical loss points where losses were considered to be highest, were at harvest, sorting and grading at the packinghouse and the display at retail marketing. The quantitative losses based on weight were estimated by the respondent from their memory or guided by the enumerators to weight at the CLPs. The percentage of losses was calculated based on total tomato harvested or processed or purchased of the day or batch at each CLP. Total post-harvest losses were obtained by cumulating the losses reported at each CLP and each level of the tomato supply chain.

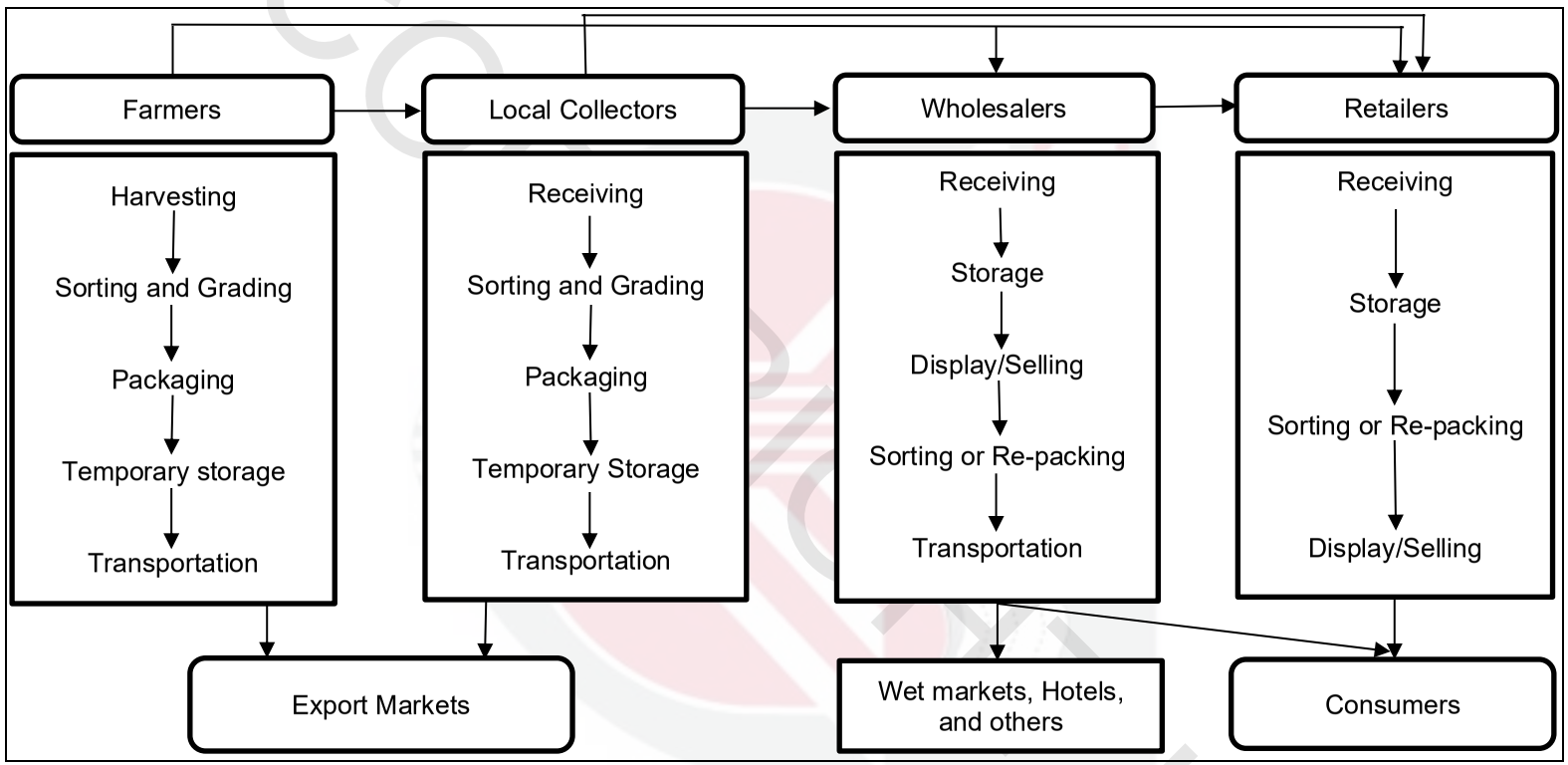

Figure 1.2: Tomato Value Chain with Postharvest Practices
[Source: Adapted from Mohammed and Craig (2018)]

1.3 Postharvest Losses and Factor Contributing to Postharvest Losses

Postharvest losses refer to a decrease in the quantity or quality of agrifood that occur along the food supply chain from the time of harvest to the final consumption by the consumer (de Lucia & Assennato, 1994; Parfitt *et al*., 2010; Kitinoja *et al*., 2011; Kiaya, 2014; Emana *et al*., 2017; Liu & Rezaei, 2017). The concept PHLs are thereby often related to the malfunctioning of the food production and supply system which may due to managerial and technical limitations, such as a lack of proper storage facilities, cold chain, proper postharvest handling practices, infrastructure, packaging, or efficient marketing systems (Parfitt *et al*., 2010; Liu & Rezaei, 2017). Hence, the causes of PHLs are not intentional.

Postharvest losses can be in the form of quantitative as measured by decreased weight or volume or can be qualitative such as reduced nutrient value and undesirable changes in taste, deterioration in texture, color, or aesthetic physical appearance of food (Buzby & Hyman, 2012). Quantitative PHLs refers to the edible food available for human consumption but being discarded and not consumed due to factors such as spillage and other unintended losses along the food supply chain (Aulakh & Regmi, 2013; Buzby & Hyman, 2012; Hodges, Buzby & Bennett, 2011). The qualitative PHLs can occur as a result of either physical changes or chemical changes, the incidence of pest and disease or postharvest handling, and by contamination of mycotoxins and pesticide residues (Aulakh & Regmi, 2013). Generally, quantitative PHLs are much easy to measure or to estimate. Whereas qualitative losses which are more subjective, more complicated, and difficult to measure directly (Kader, 2005).

In this study, PHLs refer to food that is originally intended for human consumption, regardless of causes but has been lost or wasted along the supply chain before the consumer level in mass or weight. In other words, the quantitative losses due to spillage and other unintended losses along the fresh tomato supply chain will be considered in this study as they are the ones that can be directly measured. The approach on PHLs estimation suggested by Aulakh and Regmi (2013) was adopted in this study where the amount of PHLs can first be determined at the identified critical loss points (CLPs) or targeted key process activities in each stage of the food supply chain and the total sum of PHLs at any postharvest stage will then be obtained by cumulating all food losses occurring at each of CLPs of the particular postharvest stage. For example, the PHLs at the farm level can be estimated in terms of percentage losses to the total production volume (Aulakh & Regmi, 2013; Sharma & Singh, 2011) and the losses at the collector, wholesaler and retailer levels can be estimated based on percentage losses against tomato purchased or received from the sellers.

Factors or causes contributing to postharvest losses include production practices, harvesting to handlings, processing, weather conditions, management decisions, farming experiences, sorting and grading issues, infrastructure,

attitudes, consumer preferences, and availability of financial markets and many more (Aulakh and Regmi, 2013). Overall, the literature review on PHLs of tomato was between 20-50%. Table 1.5 presents some findings on PHLs of tomato across the 4 levels of AFSC i.e. farm, collector level, wholesale, and retail markets. Losses at the farm level varied from 2% to 40% and most studies found that the losses were above 10%. The losses at retail markets varied from 3% to 50% and many were reported below 10%. If all PHLs have the same degree of variability, this indicates that there is a high level of uncertainty and skepticism about the PHLs statistics. A panel data study by Mbuk *et al.* (2011) found that PHLs of tomato retailers in Uyo, South Africa were over 50% of the total tomato production and these losses were mainly due to inappropriate postharvest handling. A trace-back study by Underhill and Kumar (2015) found that 32.9% of the harvested tomato was removed from the food supply chain due to poor temperature management, poor on-farm hygiene, rots, failure to ripe, insufficient volume to fill up a carton, physical damage during transportation and fruit being over-ripe. In Malaysia, the study of Humam *et al*. (2011) using sampling technique from 5 tomato farms in Cameron Highlands found that PHLs for tomato were 25.7% with highest at the retail stage (8.1%) followed by wholesale (7.5%), collector (5.4%) and farm (4.7%). The losses were mainly caused by mechanical injuries due to inappropriate postharvest handling and physiological disorders. Besides, a study carried out by FAO found that total PHLs for tomatoes were measured at 34 percent (11% at field harvest, 10.5% at the packinghouse, 12.5% at retail marketing) and the losses were mainly due to physical damage (compression, punctures, bruises, and shoulder scars), physiological disorder (cracks, blossom end rot, puffiness, and aesthetic defect fruits), pathological and entomological leading to unmarketable fruit (Mohammed and Craig, 2018). A recent study by Wigati *et al.* revealed that 53.2% of the total tomato production from West Java Province, Indonesia did not make it to the table where 11.2% were lost at the farm level, 10% at the middlemen level, 20.6% at retail wet market level and 11.4% the final consumer level. The unmarketable fruits were mainly because of fruits being attacked by pest and disease due to poor farm management and mechanical damage fruits due to poor postharvest handling practices such as poor and rough handling, lack of knowledge on sorting and grading process and inappropriate packaging. Another study by Abera, *et al.* (2020) revealed that PHLs of tomato of 20.5%, 8.6%, 2.9%, and 7.3% at the producers, wholesalers, retailers, and hotel and cafe level respectively were recorded with a total loss of 39.3% in Ethiopia. The losses were mainly due to poor and carelessness handling, lack of temperature management, and no/poor sorting of fruits. Field, transportation, and market display were major critical loss points identified. This PHLs research is clear evidence that PHLs of tomatoes are a problem, particularly at the farm level and it is worthy for further study overall in the fight against food insecurity.

Table 1.5: Postharvest Losses of Tomato Production

Country	PHLs (%)				Source
	F	C	WS	R	
Malaysia	4.7	5.4	7.5	8.1	Humam *et al*., 2011
Vietnam	8.0	4.0	4.0	3.0	Genova, Weinberger, An, *et al.* (2006)
Vietnam	2.0	1.0	7.0	7.0	Genova, Weinberger, Chanthasombath, *et al.*, (2006)
Cambodia	10	2.0	7.0	6.0	Genova, Weinberger, Sokhom, Vanndy, & Yarith (2006)
Cambodia	12.5	3.5	3.5	3.5	Buntong *et al.* (2013)
	12.5	-	5.0	5.0	
Jordan	5.8	4.9	1.3	4.5	Awaidah (2010)
Bangladesh	6.9	9.1	8.1	8.9	Hassan *et al.* (2010)
Fiji	26.4	0.1	-	6.4	Underhill & Kumar, (2015)
Ghana	40.0	-	-	-	Aido *et al*. (2014)
Ghana	23.7	-	-	-	Addo *et al*. (2015)
Pakistan	24.0	-	-	-	Awan *et al*. (2017)
Pakistan	20.0	-	-	-	Rehman et al. (2007)
Cameroon	36.0	-	-	-	Emmanuel and Kamtchouing (2016)
Nigeria	-	-	-	50.0	Mbuk *et al*. (2011)
Indonesia	11.2	10.0	-	20.6	Wigati *et al.* (2019)
Ethiopia	20.5	-	8.6	2.9	Abera *et al*. (2020)
India	15.2	-	-	8.0	Sharma and Singh (2011)
India	13.3	3.4	6.9	8.6	Gupta (2018)
Guyana	20.5	-	-	12.5	Mohammed and Craig (2018)

Note: F= Farm, C= Collector, WS= Wholesaler and R= Retailer
[Source: Compiled by the author (2020)]

1.4 Problem Statement

Highly perishable fruits and vegetables undergo the highest proportion of PHLs in developing countries; almost half of the fruits and vegetables produced globally do not make it to the table (Parfitt *et al*., 2011). In Malaysia, about 20-50% of the fruits and vegetables produce are lost and wasted along the agrifood supply chain. Nevertheless, the information on the PHLs of vegetables is still very limited. The lack of clear information on the real and up to date magnitude of PHLs has been identified as one of the major obstacles in the efforts to achieve PHLs mitigation (Affognon, Mutungi, Sanginga, & Borgemeister, 2015). In the absence of reliable information and estimates of PHLs, the ways to develop the

right policies and effective measures for minimizing such PHLs are becoming more difficult. There are very few studies attempted to assess the extent and magnitude of PHLs and identifying factors responsible for the PHLs in horticulture crops in Malaysia. Historically researchers in developing countries including Malaysia have primarily been focused study on how to increase the yield and very limited resources have been emphasized on the reduction of PHLs (Kitinoja *et al*., 2011). About 95% of the research resources and investments were reported focused on how to increase food production and only the balance 5% directed to study how to prevent and reducing food losses (Aulakh & Regmi, 2013; Kader, 2005). In comparison to increase production, the reduction of PHLs can be a better way to increase the returns and reduce consumer prices (Kader, 2005). There is increased acknowledgment among researchers around the world that there is a need to reduce PHLs. The situation of food availability to meet the increasing demand in the future will be changed if success is to be achieved through the reduction of PHLs. Although there is a lot of discussion on PHLs along the AFSC information on how to reduce and prevent PHLs in the upstream of the AFSC, at the primary production or farm level is still lacking (Parfitt *et al*., 2010). Based on MARDI estimates, PHLs of fruits and vegetables at the production levels are about 10-20%, 5-10% during field handling, around 5-15% at the distribution level, and 3-20% at the final consumption stage (NST, 2016). According to the study carried out by FAMA in 2014, the PHLs losses of vegetables at the farm level were 4.1-13.2%, 0.6-6.0% loss at the wholesale market, and 1.6-4.3% loss at the retailer level (NST, 2016). The PHLs at the farm level from both MARDI and FAMA was high, and this will affect the farmers' income more since farmers are not getting optimum production due to the losses. Quantifying food losses in primary production is not an easy task as the loss levels vary due to seasonal variation and the sector has not been investigated to the same extent as other levels of the FSC (Stenmark, Jensen, Quested, & Moates, 2016). Most of the studies on PHLs are focused either at the retailers' or at the consumers' levels along the FSC (WRAP, 2011). The study on PHLs from the farmers' perspective is scarce (FAO, 2011). The problem of high PHLs that usually occur on the farm is an issue in low-income countries (FAO, 2011; World Bank, 2011) include Malaysia. It is, therefore, necessary to conduct a study on PHLs along the agrifood supply chain and identifying factors influencing PHLs at the farm level. Thus, farmers can take proper steps to reduce their losses and the policymakers can identify the most effective loss-reducing measures and interventions that believed to be the most beneficial and cost-effective to address this issue.

Tomato is the most important vegetable crops in Malaysia. The total production in 2018 was 205,550 metric tonnes. In value terms, tomato production amounts to RM 558 million based on ex-farm price. In general, tomato production continues to indicate strong growth. The study of Humam *et al.* (2011) using a piecemeal approach to PHLs assessment with only five tomato farmers in Cameron Highlands revealed that PHLs from farms until retailers were 25.7% and the losses were mainly due to mechanical injuries from inappropriate postharvest handling and physiological disorder. Based on the above losses, the PHLs of tomato in 2018 were estimated to be 52,826 metric tonnes or RM 144 million in terms of value.

A study conducted by Osman *et al.* (2009) at different levels of the fruits and vegetable supply chain in Malaysia to identify postharvest handling practices that were practiced by the key players, the potential postharvest practices that can be adopted, and the factors contributing to PHLs of fruits and vegetable. They revealed that insufficient knowledge of good handling practices, inefficient/improper handling systems (attitude), insufficient and improper infrastructure, and insufficient funding were the factors contributing to PHLs to fruits and vegetables in the country. Serious considerations should thus be given to creating awareness, not only key players along the supply chain, the policymakers, and financiers. Without proper knowledge and a good attitude, the infrastructure will not be appropriately utilized and maintained. Mbuk *et al* (2011) study on factors influencing PHLs of tomato in Nigeria revealed that the adoption of a simple postharvest practice such as storing harvested tomato with paper covering was negatively correlated with the number of losses reported by the marketers However, the adoption of the practices was reported low at 6.7% only in the study area.

To the best knowledge of the author, there is no research study on postharvest losses of tomato in Cameron Highlands and Lojing Highlands using the approach of estimating the losses at the identified critical loss points of each of the key players (farmers, collectors, wholesalers, and retailers) along the supply chain. There is also no research on determining the factors that influence farmers' behavior on the adoption of postharvest practices and the factors that influence the PHLs of fresh tomato at the farm level in Cameron Highlands and Lojing Highlands. The goal of this study was to extend the effort made by previous authors by estimating the PHLs of fresh tomato production in Cameron Highlands and Lojing Highlands using a different approach, sampling method instead of tracking or direct measurement. As the losses at the farm were relatively high and farmers' income was affected the most, it is, therefore, necessary to conduct a study on determining factors influencing PHLs of tomato at the farm level. The adoption of postharvest practices is found to be negatively correlated to PHLs, it is, therefore, necessary to conduct a study on determining determinants influencing farmers' adoption on postharvest practices.

1.5 Research Questions

From the above, the research questions for this study are:

i. What is the extent of PHLs of fresh tomato production in Cameron Highlands and Lojing Highlands, Malaysia?

ii. What are the factors influencing PHLs of fresh tomato at the farm level?

iii. Is there any association between the adoption of postharvest practices with socio-economic and socio-demographic characteristics of farmers?

iv. What are the determinants that influence farmers' behavior on the adoption of postharvest practices towards reducing PHLs?

1.6 Objectives of the Study

The general objective of this study is to estimate the postharvest losses of fresh tomato production in Cameron Highlands and Lojing Highlands, Malaysia.

The specific objectives are:

i. To estimate the extent of postharvest losses of fresh tomato production in Cameron Highlands and Lojing Highlands.

ii. To determine the factors influencing postharvest losses of fresh tomato at the farm level in Cameron Highlands and Lojing Highlands.

iii. To determine farmers' socio-economic and socio-demographic characteristics associated with farmers' adoption of postharvest practices.

iv. To determine the determinants that influence farmers' behavior on the adoption of postharvest practices towards reducing PHLs of tomato.

1.7 Significance of the Study

Postharvest losses issue along the AFSC is a complex problem. In addressing the identified research gaps, it is hoped that this study adds to the body of knowledge of PHLs and AFSC literature by increasing understanding of PHLs losses problem, particularly tomato supply chain (SC) in Malaysia. Through this study, specific PHLs estimates on tomato will be identified in the Malaysia AFSC context and this could provide baseline research for future PHLs for other fruits and vegetables. To the best knowledge of the author, there is no research determining the factors that influence farmers' behavior on the adoption of postharvest practices and the factors that influence the PHLs along fresh tomato SC in Malaysia, particularly at the upstream of the tomato SC i.e. at the primary production level.

It is hoped that this study will have significant practical and policy implications. PHLs reduction means more food will be available for people and less food going to landfill. As a result, not only the livelihoods of people will be improved, food security also will be increased. Identifying effective measures and interventions based on identified factors influencing PHLs will help to preserve natural resources for the generations to come. Moreover, through this study tomato farmers will be able to assess their current postharvest practices and room for improvement on their business performance. Thus, through the findings of this

study farmers will be able to decide whether they require any changes in their existing postharvest practices towards reducing PHLs. The reduction of PHLs at the farm level will lead to overall business performance (both financial and operational) of farmers to improve. The reduction of PHLs means the reduction in energy used, raw materials usage, water usage, and human capital. As a result, the overall cost of production will be decreased, and the income of farmers will be increased. On the other hand, consumers can enjoy affordable and more reasonable food prices.

The policymakers could use these findings to devise effective interventions and measures to reduce PHLs and increase income among the farmers, particularly the smallholder farmers. Hence, policymakers should find ways to organize training for farmers to increase the level of awareness on postharvest practices towards reducing PHLs as it has a substantial impact on PHLs levels in the primary production level. The current study is therefore can act as a platform for the policymaker, government, and relevant agencies to formulate PHLs reduction measures.

1.8 Scope of the Study

To feed the rapidly increasing world population, increasing food production alone will not be able to meet future food demand due to the challenge of climate change and increasingly limited natural resources. Reducing PHLs has been recognized as another way to increase food availability, and at the same time to easing the challenge of limited natural resources and to strengthen food security. PHLs issue along the supply chain is a complex problem and proper understanding of the issues with up-to-date data and information on the losses is important to develop strategies to curb losses along the food supply chain.

In Malaysia, tomato is the most important highlands vegetable with enormous potential for domestic and export markets. The production is throughout the year and the PHLs are high along the fresh tomato supply chain. Thus, its selection for this study towards PHLs reduction is appropriate. The production of tomato is concentrated in Cameron Highlands, Pahang, and Lojing Highlands, Kelantan. The scope of the study is delimitated to only estimate the postharvest losses of fresh tomato production, from farmers to retailer levels, based on the measurement of % weight loss. But the focus will be at the upstream of the fresh tomato SC on factors influencing PHLs at the producers' level. Losses occurring at the pre-harvest and waste occurring during the final consumption stage were not factored in this study.

1.9 Organization of the Thesis

This thesis is organized into 5 chapters covering different areas of the study. Chapter 1 is the introduction, gives a wider knowledge about postharvest losses,

and a clear picture of the problem involved in conducting the study. It consists of a background of the research problem, the problem statement, objectives, and significance of the study, scope, and limitation of this study. Chapter 2 provides literature reviews of the most recent and relevant studies in this field. Chapter 3 provides the methodology and data source. Chapter 4 discusses and presents the results based on the objectives of this study, including the socio-economics characteristics of tomato farmer respondents, estimation of PHLs fresh tomato production along the AFSC, factors influencing PHLs, and causes of losses. Chapter 5 The concluding section summarizes the major findings, contributions of the study, and recommendations for future studies.

REFERENCES

Abdullah, A. M., Arshad, F. M., & Latif, I. A. (2011). The Impacts of Supermarkets And Hypermarkets From The Perspectives of Fresh Fruit and Vegetables (FFV) Wholesalers and Retailers. *Journal of Agribusiness Marketing, Vol. 4, December 2011, p. 21-37.*

Abdullah, W. W., Aminuddin, B. Y., Salama, R. B., Cheah, U. B., Jamaluddin, J., & Osman, G. (2001). Site descriptions and project field activities in the Cameron Highlands. In *ACIAR PROCEEDINGS* (pp. 3-9). ACIAR; 1998.

Abera, G, Ibrahim, A. M., Forsido, S. F., and Kuyu, C. G. (2020). Assessment of post-harvest losses of tomato (Lycopersicon esculentemMill.)in selected districts of East Shewa Zone of Ethiopia using a commodity system analysis methodology. Heliyon 6. CelPress. https://doi.org/10.1016/j.heliyon.2020.e03749

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

Adeoye, I. B., Odeleye, O. M. O., Babalola, S. O., & Afolayan, S. O. (2009). Economic analysis of tomato losses in Ibadan metropolis, Oyo State, Nigeria. *African Journal of Basic and Applied Sciences*, *1*(5-6), 87-92.

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

Adesina, A. A., and Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from the analysis in Burkina Paso and Guinea, West Africa. Agricultural Economics 13 (1995) 1-9.

Adewumi, M. O., Ayinde, O. E., I., F. O., & Olatunji, G. B. (2009). Analysis of postharvest losses among šlantain/banana (Musa Spp. L.) marketers in Lagos State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment.*, *5*(2–4), 35–38.

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis. *World Development*, *66*, 49-68.

Ahmed, U. I., Ying, L., Mushtaq, K., & Bashir, M. K. (2015). An econometric estimation of post-harvest losses of kinnow in Pakistan. *International Journal of Economics, Commerce and Management*, *3*(5), 373-383.

Aijuka, M., Charimba, G., Hugo, C. J., & Buys, E. M. (2015). Characterization of bacterial pathogens in rural and urban irrigation water. *Journal of water and*

health, *13*(1), 103-117.

Ainembabazi, J. H., & Mugisha, J. (2014). The role of farming experience on the adoption of agricultural technologies: Evidence from smallholder farmers in Uganda. *Journal of Development Studies*, *50*(5), 666-679.

Aini, Z., Sivapragasam, A., Vimala, P., and Mohamad Roff, M. N. (2005) Organic vegetable cultivation in Malaysia. Chapter 8. Harvesting and postharverst handling. Malaysian Agriculture Research and Development Institute. p147-160

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Akudugu, M. A., Guo, E., & Dadzie, S. K. (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions. *Journal of Biology, Agriculture and Healthcare*, *2*(3), 1–14.

Alidu, A. F., Ali, E. B., & Aminu, H. (2016). Determinants of Post Harvest Losses among Tomato Farmers in The Navrongo Municipality in The Upper East Region. *Journal of Biology, Agriculture and Healthcare*, *6*(12), 14-20.

Arah, I. K., Kumah, E. K., Anku, E. K., & Amaglo, H. (2015). An overview of post-harvest losses in tomato production in Africa: causes and possible prevention strategies. *Journal of Biology, Agriculture and Healthcare*, *5*(16), 78-88.

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

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Arazuri, S., Arana, I., & Jaren, C. (2010). Evaluation of mechanical tomato harvesting using wireless sensors. *Sensors*, *10*(12), 11126-11143.

Arshad, F. M. (2010). New Agrifood Marketing System for Fresh Fruits and Vegetables In Malaysia: Some Structural Perspectives. *Journal of Agribusiness Marketing, Special edition, October 2010, p. 28-68.*

Arshad, F. M., Mohamed, Z., & Latif, I. (2006, November). Changes in agrifood supply change in Malaysia: Implications of marketing training needs. In *Proceedings of the O/AFMA/FAMA Regional Workshop on Agricultural Marketing Training, Food and Agriculture Organization of United Nations (FAO) and Agricultural and Food Marketing Association for Asia and the Pacific (AFMA)*.

Arumugam, N., Arshad, F. M., & Mohamed, Z. (2011). Determinants of Fresh

Fruits and Vegetables (FFV) Farmers' Participation in Contract Farming in Peninsular Malaysia. *International Journal of Agricultural Management and Development (IJAMAD)*, *1*(2), 65–71.

Atanda, S. A., Pessu, P. O., Agoda, S., Isong, I. U., & Ikotun, I. (2011). The concepts and problems of post-harvest food losses in perishable crops. *African Journal of Food Science*, *5*(11), 603-613.

Aulakh, J., & Regmi, A. (2013). Post-harvest food losses estimation-development of consistent methodology. *Rome: FAO*, 4-9.

AVA. (2017). AVA Clarifies on the safety of imported vegetables. Retrieved from https://www.reach.gov.sg/participate/discussion-forum/2017/02/02/ava-clarifies-on-safety-of-imported-vegetables

Awaidah, M. (2010). An overview on postharvest sector in Jordan. *2010 AARDO Workshop on Technology on Reducing Post-Harvest Losses and Maintaining Quality of Fruits and Vegetables*, 125–140.

Awan, M. S., Hussain, A., Abbas, T., & Karim, R. (2012). Assessment of production practices of small- scale farm holders of tomato in Bagrote Valley, CKNP region of Gilgit-Baltistan, Pakistan. *Acta Agriculturae Slovenica*, *99*(2), 191-99.

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

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

Baha, M. R., & Msafiri, M. (2016, October). B15 Post-harvest food losses: a framework for horticulture sub-sector analysis in sub-Saharan Africa. In *Proceedings ICAS VII Seventh International Conference on Agricultural Statistics, Rome. Department of Economics and Statistics. The University of Dodoma, Dodoma* (pp. 24-26).

Bani, R.J., Josiah, M.N., E.Y. Kra, E. Y. (2006). Postharvest losses of tomatoes in transit. *AMA, Agricultural Mechnization in Asia, Africa, and Latin America*, *37*(2), 84–86.

Basavaraja, H., Mahajanashetti, S. B., & Udagatti, N. C. (2007). Economic analysis of post-harvest losses in food grains in India: a case study of Karnataka. *Agricultural Economics Research Review*, *20*(347-2016-16622), 117-126.

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

Bryman, A. (2012). *Social Research Methods*. *Oxford University Press* (4th Edition).

Buntong, B., Srilaong, V., Wasusri, T., Kanlayanarat, S., & Acedo Jr, A. L. (2013). Reducing postharvest losses of tomato in traditional and modern supply chains in Cambodia. *International Food Research Journal*, *20*(1), 233.

Burns, R. P., & Burns, R. (2008). *Business research methods and statistics using SPSS*. Sage.

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

Buzby, J. C., Farah-Wells, H., & Hyman, J. (2014). The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States. *USDA-ERS Economic Information Bulletin*, (121). https://doi.org/10.2139/ssrn.2501659

CEC. (2017). *Characterization and management of food loss and waste in North America.* Montreal, Canada.

Chai, E. M. (2017). *Discussion with the secretary of Cameron Highlands vegetable grower association*.

Chan, N. W., Suriati, G., & Norizan, M. N. (2006). Climate change and Heat Island Effects in Camaron Highlands. In N. W. Chan (Ed.), *Cameron Highlands Issues & Challenges in Sustainable Development* (p. 169). Penang, Malaysia: School of Humanities, Unversity of Science Malaysia. Retrieved from http://eprints.usm.my/10498/1/Cameron_Highlands_Issues-Challenges_In_Sustainable_Development.pdf

Changule, R.B., Shelke, R.D., and Mane, B.B. (2011). An economic evaluation of postharvest losses in tomato in Latur district of Maharashtra, Internat. Res. J. agric. Eco. & Stat., 2 (1) : 38-41.

Cherono, K., and Workneh, T. S. (2018). A review of the role of transportation on the quality changes of fresh tomatoes and their management in South Africa and other emerging markets. International Food Research Journal 25(6): 2211-2228 (December 2018)

Cohen, L.; Manion, L.; M. K. (2012). *Research methods in education*. *Professional Development in Education* (Vol. 38).

Cresswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (Fourth Edi). London, UK: Sage Publications Inc.

David J. Bartholomew, Martin Knott, I. M. (2011). *Latent Variable Models and Factor Analysis: A Unified Approach Latent Variable Models and Factor Analysis: A Unified Approach By David J. Bartholomew, Martin Knott, Irini*

Moustaki (3rd Editio). United Kingdom: John Wiley & Sons, Ltd.

de Lucia, M., and Assennato, D. (1994). Agricultural engineering in development - Post-harvest operations and management of food grains. *FAO Agricultural Services Bulletin No. 93*, *No 93*.

Dikko, M. (2016). *Establishing Construct Validity and Reliability: Pilot Testing of a Qualitative Interview for Research in Takaful (Islamic Insurance)*. *The Qualitative Report* (Vol. 21). https://doi.org/10.1109/APCAP.2012.6333220

DOA. (2017). Interview with Agriculture office, Shazawan, Department of Agriculture, District of Cameron Highlands, Pahang.

DOA. (2019). Statistik Tanaman (Sub-sektor tanaman makanan) 2018. Jabatan Pertanian Semenanjung Malaysia. Retrieved from http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/perangkaan_sayur_tnmn_ladang_2018.pdf

Dohare, R. K., Vijayaraje, R., Krishi, S., & Vidyalaya, V. (2014). A study on awareness and adoption of post-harvest management practices in tomato cultivation among the farmers in Sehore District M. P. In Rajesh Kumar Dohare Department of Extension Education & Rural Sociology Certificate-I.

DOSM. (2017). *Supply and Utilization Account SelectedAgricultural Commodities, Malaysia 2012-2016*. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=164&bul_id=UDROQllWME5ETGZrcUE5VnAzcHJEQT09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09

DOSM. (2018). *Supply and Utilization Account SelectedAgricultural Commodities, Malaysia 2013-2017*. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=164&bul_id=ZE12RXM2SDM1eGRxRXR3bU0xRThrUT09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09

DOSM. (2019). *Supply and Utilization Account SelectedAgricultural Commodities, Malaysia 2014-2018*. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=164&bul_id=Tm5OaVh6RFpFM2VGOTIrZzltbWg3QT09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09

DOSM. (2020). Pocket Stats Quarter 1 2020. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/cone&menu_id=K3BnY0JCeXZidmZWVnAzVkJpRVVOdz09

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

Emmanuel, T. L. D., and Kamtchouing, P. (2016). *Dynamics of losses in tomato commodity chain (estimates based on experimental design in Cameroon). Proceedings ICAS VII. Seventh International Conf. Agric. Stat.* 546-555

Esguerra, E. B., and Rolle, R. (2018) Post-harvest management of tomato for quality and safety assurance Guidance for horticultural supply chain stakeholders. Food and Agriculture Organization of the United Nations, Rome. Retrieved from: http://www.fao.org/3/I8236EN/i8236en.pdf

FAMA. (2010). *Tomato Quality Based on Malaysian Standard MS 893:2010*.

FAO. (2011). *Global food losses and food waste - Extent, causes, and prevention. SAVE FOOD: An initiative on Food Loss and Waste Reduction*. Rome. https://doi.org/10.1098/rstb.2010.0126

FAO. (2013a). *Food wastage footprint. Impacts on natural resources. Summary Report*. *Food wastage footprint Impacts on natural resources*. https://doi.org/ISBN 978-92-5-107752-8

FAO. (2013b). *Toolkit- Reducing the Food Wastage Footprint*.

FAO. (2014a). Food Loss Assessments : Causes and Solutions. *Case Studies in Small-Scale Agriculture and Fisheries Subsectors*, 92. Retrieved from http://www.fao.org/fileadmin/user_upload/save-food/PDF/Kenya_Food_Loss_Studies.pdf

FAO. (2014b). *Working paper Definitional framework of save food : Global Initiative on Food Loss and Waste Reduction Definitional framework of food loss*.

FAO. (2017). *The future of food and agriculture: Trends and challenges. Fao*. https://doi.org/ISBN 978-92-5-109551-5

FAO, & WHO. (2003). Assuring Food Safety and Quality. *Who/Fao*, 3. https://doi.org/10.1088/0004-637X/790/2/128

Feder, G., & Umali, D. L. (1993). Special Issue Technology and Innovation In Agriculture and Natural ResourcesThe adoption of agricultural innovations. *Technological Forecasting and Social Change*, *43*(3), 215–239. https://doi.org/http://dx.doi.org/10.1016/0040-1625(93)90053-A

Fehr, M., & Romão, D. C. (2001). Measurement of fruit and vegetable losses in Brasil: a case study. *Environment, Development, and Sustainability*, *3*, 253–263.

Feng, S. Q. (2001). Problems and countermeasures in postharvest handling of fruits and vegetables in China. *Postharvest Handling of Fresh Vegetables, ACIAR Proceedings*, (105), 8–11.

Field, A. (2009). *Discovering Statistics Using SPSS*. *Sage Publication* (Vol. 58).

https://doi.org/10.1234/12345678

Florkowski, W. J., Shewfelt, R. L., Brueckner, B., & Prussia, S. E. (2014). *Postharvest handling a system approach* (Third Edit). San Diego, USA: Academic Press.

Foresight. (2011a). Foresight Project: C1: Trends in food demand and production, 40.

Foresight, T. F. of F. and F. (2011b). The Future of Food and Farming : Challenges and choices for global sustainability The Future of Food and Farming : Challenges and choices for. https://doi.org/10.1111/j.1365-2745.2004.00964.x

Fox, T. (2013). Global Food: Waste Not, Want Not. *Institution of Mechanical Engineers*, *23*(1), 23–50.

Frank, S., Witzke, H., Zimmermann, A., Havlík, P., & Ciaian, P. (2014). Climate change impacts on European agriculture : a multi-model perspective, 1–15.

Gajbhiye, D. T.; Kukade, N. N.; Bagde, N. T.; Burade, A. L. (2008). An economic analysis of post-harvest losses of selected vegetables in Nagpur district. *Journal of Soils and Crops*, *18*(2), 469–472 ref.3.

Gangwar, L. S., Singh, D., & Singh, D. B. (2007). Estimation of Post-Harvest Losses in Kinnow Mandarin in Punjab Using a Modified Formula. *Agricultural Economics Research Review*, *20*(December), 315–331.

Garnett, T. (2006). Fruit and Vegetables & Uk Greenhouse Gas Emissions : Exploring the Relationship Working Paper Produced As Part of the Work of the Food Climate. *Food Climate Research Network*, 1–134.

Genova II, C., Weinberger, K., An, H., Dam, D., Loc, N., Thinh, L., & Thuy, N. (2006). *Postharvest loss in the supply chain for vegetables: The case of chili and tomato in Viet Nam*. *AVRDC Working Paper*. Retrieved from http://www.avrdc.org/pub_socio.html

Genova II, C., Weinberger, K., Chanthasombath, T., Inthaluugdsee, B., Sanatem, K., & Somsak, K. (2006). *Postharvest loss in the supply chain for vegetables: The case of tomato, yardlong bean, cucumber, and Chili in LAO PDR* (No. 17).

Genova II, C., Weinberger, K., Sokhom, S., Vanndy, M., & Yarith, E. C. (2006). *Postharvest loss in the supply chain for vegetables: The case of tomato, yardlong bean, cucumber, and Chinese kale in Cambodia*. *AVRDC Working Paper*. Retrieved from http://www.avrdc.org/pub_socio.html

Gonzales, L. M. R., Aban, M. L., & Acedo Jr, A. L. Supply Chain Mapping and Postharvest Losses of Cabbage in Traditional and Modern Chains in Cebu, Philippines.

Grolleaud, M. (2002). *Post-harvest Losses: Discovering the Full Story. Overview of the Phenomenon of Losses during the Post-harvest System*. Rome, Italy: FAO, Agro Industries, and Post-Harvest Management Service.

Gunders, D. (2012). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. *NRDC Issue Paper*, (August), 1–26. https://doi.org/12-06-B

Gupta, P.K. (2018). Value chain study of tomato of Karnal, Haryana, India. 2017-18. National Horticultural Research & Development Foundation. Retrieved from: https://midh.gov.in/VCS%20Reports/18-Tomato%20Value%20Chain%20Karnal%20Haryana.pdf

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis*. *Pearson custom library*. https://doi.org/10.1038/259433b0

Hassan, M. K., Chowdhury, B. L. D., & Akhter, N. (2010). *Post Harvest Loss Assessment : A Study to Formulate Policy for Loss Reduction of Fruits and Vegetables and Socioeconomic Uplift of the Stakeholders*.

Henz, G. P. (2017). Postharvest losses of perishables in Brazil: what do we know so far? *Horticultura Brasileira*, *35*(1), 6–13. https://doi.org/10.1590/s0102-053620170102

Hewett, E. W. (2006). An overview of preharvest factors influencing postharvest quality of horticultural products. *International Journal of Postharvest Technology and Innovation*, *1*(1), 4. https://doi.org/10.1504/IJPTI.2006.009178

Hinton, P. R. (2004). *Statistics Explained* (2nd Editio). London and New York: Routledge.

HLPE. (2014). Food Losses and Waste in the Context of Sustainable Food Systems. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. *HLPE Report*, (June), 1–6. https://doi.org/65842315

Hodges, R. (2013). How to assess postharvest cereal losses and their impact on grain supply : rapid weight loss estimation and the calculation of, *2013*(July).

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *Journal of Agricultural Science*, *149*(S1), 37–45. https://doi.org/10.1017/S0021859610000936

Humam, M., Mahmud, T.M.M., Ahmad, S.H., and Selamat, A. (2011). Estimation of Postharvest Losses at Various Stages of the Supply Chain for Tomato (Lycopersicum esculentum) and Cabbage (Brassica oleracea var. Capitata). *Trans. Malaysian Soc. Plant Physiol.*, *19*(ISBN 978-967-10840-

0-7), 47–49.

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

Iglesias A., Quiroga S., D. A. (2011). Looking into the future of agriculture in a changing climate. *European Review of Agricultural Economics*, *38*(3), 427–447. Retrieved from https://doi.org/10.1093/erae/jbr037

Kader, A. A. (2010). Handling of horticultural perishables in developing vs. developed countries. *Acta Horticulturae*, *877*, 121–126. https://doi.org/10.17660/ActaHortic.2010.877.8

Kader, Adel A. (2005). Increasing Food Availability by Reducing Postharvest Losses of Fresh Produce, 2169–2176.

Kader, Adel A., & Rolle, R. S. (2004). *The role of post-harvest management in assuring the quality and safety of horticultural produce*. *Fao Agricultural Services Bulletin*.

Kader, Adel A. (2013). Postharvest Technology of Horticultural Crops - An Overview from Farm to Fork, *8*(1), 1–8.

Kaguongo, W., Maingi, G., Giencke, S. (2014). *Post-harvest losses in potato value chains in Kenya Table of Contents*.

Karkie, L. B., & Bauer, S. (2004). Technology Adoption and Household Food Security. Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in. *Rural Poverty Reduction through Research for Development*, 8. Retrieved from http://www.tropentag.de/2004/abstracts/full/107.pdf

Kasso, M., & Bekele, A. (2016). Post-harvest loss and quality deterioration.

Kiaya, V. (2014). Post-Harvest losses and Strategies to Reduce Them. *ACF International*, (January), 1–25.

Kitinoja, L., & AlHassan, H. Y. (2012). VOLUME 1-Postharvest Handling and Loss Reduction-Identification of Appropriate Postharvest Technologies for Small Scale Horticultural Farmers and Marketers in Sub-Saharan Africa and South Asia—Part 1. Postharvest Losses and Quality Assessments. *Acta Horticulturae*, (934), 31.

Kitinoja, L.; Gorny, J. R. (1999). Postharvest technology for small-scale produce marketers: economic opportunities, quality, and food safety. In *Postharvest Horticulture Series - Department of Pomology, University of California 1999 No.21 pp.viii* (p. 365).

Kitinoja, L., and Cantwell, M. (2010). Identification of appropriate postharvest

technologies for improving market access and incomes for small horticultural farmers in Sub-Saharan Africa and. *… in Three Parts for the IHC Postharvest …*, (52198), 1–29.

Kitinoja, L., & Kader, A. A. (2003). Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (4, (8).

Kitinoja, L., & Kader, A. A. (2015a). Measuring postharvest losses of fresh fruits and vegetables in developing countries. *PEF White Paper*, 15-02.

Kitinoja, L., & Kader, A. A. (2015b). Small-scale postharvest handling practices. A manual for horticultural crops. University of California, Davis. Postharvest Technology Research and Information Center.

Kitinoja, Lisa. (2016). Innovative Approaches to Food Loss and Waste Issues Brookings Institution ' s, (April).

Kitinoja, Lisa, Saran, S., Roy, S. K., & Kader, A. A. (2011). Postharvest technology for developing countries: Challenges and opportunities in research, outreach, and advocacy. *Journal of the Science of Food and Agriculture*. https://doi.org/10.1002/jsfa.4295

Kojo, I., Ernest, A., Kumah, K., Kosi, E., & Harrison, A. (2015). An Overview of Post-Harvest Losses in Tomato Production in Africa : Causes and Possible Prevention Strategies, *5*(16), 78–89.

Kong, S. H. (2014). Bumper crop leads to tomato glut in Cameron Highlands. *The Sun Daily*. Retrieved from http://www.thesundaily.my/news/1032978

Krzywoszynska, A. (2011). Waste : Uncovering the scandal, *96*(March), 101–104.

Kumar, Deepak, and Kalita, P. (2017). Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing CountriesNo Title. *Foods*, *6*(1). https://doi.org/10.3390/foods6010008

Kumar, A., & Kushwaha, G. S. (2014). Food supply chain management sustainability: a review. *Research Journal of Science & IT Management*, *3*(10), 30–42. Retrieved from http://kar.kent.ac.uk/26066/

Kumar, D. K., Basavaraja, H., & Mahajanshetti, S. B. (2006). An economic analysis of post-harvest losses in vegetables in Karnataka. *Indian Journal of Agricultural Economics*, *61*(902-2016-66790).

Kummu, M., de Moel, H., Porkka, M., Siebert, S., Varis, O., & Ward, P. J. (2012). Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertilizer use. *Science of the Total Environment*, *438*(September 2012), 477–489. https://doi.org/10.1016/j.scitotenv.2012.08.092

La Gra, J., Kitinoja, L., and Alpizar, K. (2016). *Commodity Systems Assessment Methodology Commodity Systems Assessment Methodology*. San Jose, Costa Rica: Inter-American Institute for Corporation on Agriculture (IICA).

Ladapo, M.A, and Oladele, O. I. (2011). Effect of Knowledge, Attitude, and Constraints on Postharvest Losses among Plantain farmers and Wholesalers in South-Western Nigeria. *Life Science Journal*, *8*(2), 476–482. https://doi.org/10.1017/CBO9781107415324.004

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R., and Searchinger, T. (2013). *Reducing food loss and waste.pdf*. https://doi.org/10.2499/9780896295827_03

Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S., & Branca, G. (2015). *Climate-Smart Agriculture: Building Resilience to Climate Change*. https://doi.org/10.1007/978-3-319-61194-5

Liu, B. & Rezaei, M. (2017). FOOD LOSS AND WASTE, (July), 26–27. Retrieved from http://www.fao.org/3/a-bt300e.pdf

Liu, G. (2013). Food losses and food waste in China : a first estimate, (v).

Liu, J., Lundqvist, J., Weinberg, J., & Gustafsson, J. (2013). Food losses and waste in china and their implication for water and land. *Environmental Science and Technology*, *47*(18). https://doi.org/10.1021/es401426b

Loeb, S., Dynarski, S., Mcfarland, D., Morris, P., Reardon, S., & Reber, S. (2017). Descriptive analysis in education : A guide for researchers, (March).

Loevinsohn M, Sumberg J, & Diagne A. (2012). *Under what circumstances and conditions does the adoption of technology result in increased agricultural productivity? Protocol*. London.

Lokhande, V. K. (2010). *A Study on Adoption Behaviour of Tomato Production Technology in Chhindwara*. College of Agriculture Jabalpur (MP).

Macheka, L., Spelt, E. J., Bakker, E. J., van der Vorst, J. G., & Luning, P. A. (2018). Identification of determinants of postharvest losses in Zimbabwean tomato supply chains as a basis for dedicated interventions. *Food Control*, *87*, 135-144.

Major S Dhaliwal. (2017). Handbook of Vegetable Crops. Chapter 2 Classification of Vegetable Crops (3rd ed.). Kalyani Publisher.

Man, N., Nawi, N. M. &, & Ismail, M. M. (2009). An Overview of the Supply Chain Management of Malaysian Vegetable and Fruit Industries Focusing on the Channel of Distribution. *Journal of Agribusiness Marketing*, *2*, 1–18.

Martins, A. G., Goldsmith, P., & Moura, A. (2014). Managerial factors affecting

post-harvest loss: the case of Mato Grosso Brazil. *International Journal of Agricultural Management*, *Volume 03*(Number 4), 1–10. https://doi.org/10.5836/ijam/2014-04-03

Mbuk, E. M., Bassey, N. E., Udoh, E. S., & Udoh, E. J. (2011). Factors influencing postharvest loss of tomato in the Urban market in Uyo, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, *7*(2), 40-46.

Mebratie, M. A. (2015). Determinants of Postharvest Banana Loss in the Marketing Chain of Central Ethiopia, *37*.

Meijer, S. S., Catacutan, D., Ajayi, O. C., & Sileshi, G. W. (2015). The role of knowledge, attitudes, and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub- Saharan Africa. *International Journal of Agricultural Sustainability*, *13*(1), 40–54. https://doi.org/10.1080/14735903.2014.912493

Mena, C., Adenso-Diaz, B., & Yurt, O. (2011). The causes of food waste in the supplier–retailer interface: Evidence from the UK and Spain. *Resources, Conservation and Recycling*, *55*(6), 648–658.

Minten, B., Reardon, T., Gupta, S. D., Hu, D., & Murshid, K. A. S. (2016). Wastage in food value chains in developing countries: evidence from the potato sector in Asia. In *Food Security in a Food Abundant World*. Emerald Group Publishing Limited.

MOA. (2010). *Economic Transformation Programme A Roadmap for Malaysia: Transitioning from Agriculture to Agribusiness*. Retrieved from http://www.moa.gov.my/documents/10157/c65bb64f-da6c-4e83-bb51-40a1a55b9954

MOA. (2015). *Agrofood Statistics 2014*. Retrieved from http://www.moa.gov.my/documents/10157/010b6921-c643-421d-aef1-29ae379f6f85

MOA. (2016). *Agrofood Statistics 2015*. Retrieved from http://www.moa.gov.my/documents/10157/0e0596cf-203b-474e-ba02-8e018ce68433

MOA. (2017). Agrofood Statistics 2016. Retrieved from https://www.moa.gov.my/documents/20182/29034/Perangkaan+Agromakanan+2016_new-min.pdf/fbaac259-7f29-422e-ab5d-02d5f7d79718

MOA. (2019). Agrofood Statistics 2018. Retrieved from https://www.moa.gov.my/documents/20182/29034/Perangkaan+Agromakanan+2018.pdf/56b191f9-1e19-4368-8497-b56cf6d7b538

Mohammed, M. (2014). *Manual on Postharvest Management Strategies to Reduce Losses of Perishable Crops*.

Mohammed, M., and Craig, K. (2018). *Food loss analysis: causes and solutions*. Case study on the tomato value chain in the Republic of Guyana. Food and Agriculture Organization of the United Nations, Rome, 2018.

Moller, H., Hanssen, O. J., Svanes, E., & et. al. (2014). *Standard approach on quantitative techniques to be used to estimate food waste levels*.

Monte, J. A., De Carvalho, D. F., Medici, L. O., Da Silva, L. D. B., & Pimentel, C. (2013). Growth analysis and yield of a tomato crop under different irrigation depths. *Bras. Eng. Agríc. Ambiental*, *17917*(9), 926–931.

Morris, K.J. K. (2017). Potential of Adoptiong Small Scale Postharvest Practices Towards Reducing Plantain Supply Chain Food Losses in River State, Nigeria. (Doctoral Thesis, UPM.

Morris, K.J. K., Kamarulzaman, N. H. (2014). Conceptual Framework for Estimating Postharvest Losses in Food Supply Chains: the Case of Plantain Fruits in Nigeria. International Journal of Business and Economics Research. Special Issue: Supply Chain Management: Its Theory and Applications. Vol. 3, No. 6-1, 2014, pp. 31-37. doi: 10.11648/j.ijber.s.2014030601.15

MPC. (2015). *Productivity Report 2014/2015*. Retrieved from http://www.mpc.gov.my/wp-content/uploads/2016/04/Productivity-Report-201415.pdf

Muhammad, R.H., Hionu, G.C. and Olayemi, F.F. (2012), "Assessment of the post-harvest knowledge of fruits and vegetable farmers in Garun Mallam L.G.A of Kano, Nigeria", International Journal of Development and Sustainability, Vol. 1 No. 2, pp. 510–515.

Munhuewyi, K. (2012). *Postharvest losses and changes in quality of vegetables from retail to consumer: a case study of tomato, cabbage and carrot* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Mwangi, M., & Kariuki, S. (2015). Factors Determining the Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. *Journal of Economic and Sustainable Development*, *6*(5), 208–216. Retrieved from www.iiste.org

Noordzij, M., Tripepi, G., Dekker, F. W., Zoccali, C., Tanck, M. W., & Jager, K. J. (2010). Sample size calculations: basic principles and common pitfalls. *Nephrology dialysis transplantation*, *25*(5), 1388-1393.

Ntshangase, N. L., Muroyiwa, B., & Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal province. *Sustainability (Switzerland)*, *10*(2). https://doi.org/10.3390/su10020555

Nyagaka, D. O., Obare, G. A., & Nguyo, W. (2009). Economic Efficiency of Smallholder Irish Potato Producers in Kenya : A Case of Nyandarua North

District Economic Efficiency of Smallholder Irish Potato Producers in Kenya : A Case of Nyandarua North District Abstract. *Agricultural Economics*, 1–19.

Obayelu, AE; Ajayi, OD; Oluwalana, EOA, and Ogunmola, O. (2017). What Does Literature Say About the Determinants jig of Adoption of Agricultural Technologies by Smallholders Farmers? *Agricultural Research & Technology: Open Access Journal*, *6*(1). https://doi.org/10.19080/artoaj.2017.06.555676

Ochieng, J., Kessy, R., Afari-Sefa, V., & Chagomoka, T. (2018). Awareness, perceptions, and factors affecting purchase decisions of solar-dried vegetables in rural Tanzania. 30th International Conference of Agricultural Economists. July 28 – August 2, 2018. Vancouver.

Okiror, P., Lejju, J. B., Bahati, J., Rugunda, G. K., & Sebuuwufu, C. I. (2017). Maturity indices for tomato (Solanum lycopersicum L.), cv. Ghalia 281 in Central Uganda. *African Journal of Agricultural Research*, *12*(14), 1196–1203. https://doi.org/10.5897/AJAR2017.12150

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

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I., & Awagu, E. F. (2012). Assessment of postharvest losses of some selected crops in eight local government areas of rivers state, Nigeria. *Asian journal of rural development*, *2*(1), 13-23.

Osman, A., Saari, N., Saleh, R., Bakar, J., Zainal, N. D., & Yacob, M. (2009). Postharvest handling practices on selected local fruits and vegetables at different levels of the distribution chain. *Journal of Agribusiness Marketing, Vol. 2, December 2009, p. 39-53.*

Othman, K. I., Karim, M. S. A., Karim, R., Adzhan, N. M., & Halim, N. A. (2013). Consumption Pattern on Fruits and Vegetables among Adults: A Case of Malaysia. *Academic Journal of Interdisciplinary Studies*, *2*(8), 424–430. https://doi.org/10.5901/ajis.2013.v2n8p424

Paliyath, G., Murr, D. P., Handa, A. K., & Lurie, S. (2008). *Postharvest Biology and Technology of Fruits, Vegetables, and Flowers*.

Pannell, D. J., Marshall, G., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture*, *46*(11), 1407–1424. Retrieved from http://www.publish.csiro.au/nid/72/paper/EA05037.htm

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical*

transactions of the royal society B: biological sciences, *365*(1554), 3065-3081.

Piadozo, M. E. S., Fujishima, H., Fujimoto, A., & Shimizu, K. (2007). Problems of the Marketing System for Vegetables Grown in the Highlands in the Philippines : A Case Study of Vegetables Grown in Benguet and Laguna. *104*, 101–113.

Piali Halder; Simayan Pati. (2012). A Need for Paradigm Shifts to Improve Supply Chain Management of Fruits & Vegetables in India. *Asian Journal of Agriculture and Rural Development*, *1*, 1–20.

Porter, S. D., Reay, D. S., Bomberg, E., & Higgins, P. (2018). Avoidable food losses and associated production-phase greenhouse gas emissions arising from the application of cosmetic standards to fresh fruit and vegetables in Europe and the UK. *Journal of Cleaner Production*, *201*, 869–878. https://doi.org/10.1016/j.jclepro.2018.08.079

Prasad, P., & Kochhar, A. (2014). Active packaging in the food industry: a review. *Journal of Environmental Science, Toxicology and Food Technology*, *8*(5), 1-7.

Prusky, D. (2011). Reduction of the incidence of postharvest quality losses, and future Prospects. *Food Security*, *3*(4), 463–474. https://doi.org/DOI10.1007/s12571-011-0147-y

Quested, T., & Johnson, H. (2009). *Household Food and Drink Waste in the UK: A Report Containing Quantification of the Amount and types of Household Food and Drink Waste in the UK. Report Prepared by WRAP (Waste and Resources Action Programme), Banbury.*

Rakesh. (2016). *A study on the adoption behavior of farmers about mustard production technology in the Morar block of Gwalior district (Madhya Pradesh)*. College of Agriculture, Gwalior (M.P.).

Rana, R., & Singhal, R. (2015). Chi-square Test and its Application in Hypothesis Testing, *1*(1), 215–217. https://doi.org/10.4103/2395-5414.157577

Regmi, A., Deepak, M. S., Seale Jr, J. L., & Bernstein, J. (2001). Cross-country analysis of food consumption patterns. *Changing the structure of global food consumption and trade*, *1422*.

Rehman, M., Khan, N., & Jan, I. (2007). Postharvest losses in tomato crop (A Case of Peshawar Valley). *Sarhad Journal Agric.*, *23*(4).

Riccioni, G., Mancini, B., Ilio, E. D. I., Bucciarelli, T., & Orazio, N. D. (2008). Protective effect of lycopene in. *Eurpean Review for Medical and Pharmacological Sciences*, *12*(NOVEMBER 2007), 183–190.

Robert, A., Rita, a. D., & James, O. M. (2014). Determinants of postharvest

losses in tomato production in the Offinso North District of Ghana. *Journal of Development and Agricultural Economics*, *6*(8), 338–344. https://doi.org/10.5897/JDAE2013.0545

Rogers, E. M. (1995). Diffusion of innovations. *New York: Free Press.*

Rogers, E. M. (2002). Diffusion of preventive innovations. *Addictive Behaviors*, *27*, 989–993.

Rosa S. Rolle. (2006). *Improving postharvest management and marketing in the Asia-Pacific region: issues and challenges trends. Postharvest Management of Fruit and Vegetables in the Asia-Pacific*. (Rosa S. Rolle, Ed.). Asian Productivity Organization and FAO.

SAI, M. (2010). *Study on the development activities of Lojing Highlands and ITS*. Malaysia. Retrieved from https://environmental-auditing.org/media/5384/wg17-555-malaysia-paper.pdf

Samantha Boh. (2016). 3-5% of veggies and fruits exceeded pesticide limits. *Straits Times*. Retrieved from https://www.straitstimes.com/singapore/3-5-of-veggies-fruit-exceeded-pesticide-limits

Saran, S., Roy, S. K., & Kitinoja, L. (2012). Appropriate postharvest technologies for small scale horticultural farmers and marketers in sub-Saharan Africa and South Asia -Part 2. Field trial results and identification of research needs for selected crops. *Acta Horticulturae*, *934*, 41–52. https://doi.org/Acta Hort. 934, ISHS 2012

Shareef, Mahmud Akhter; Kumar, Vinod; Kumar, Uma; Hasin, A. A. (2009). Theory of Planned Behavior and Reasoned Action in Predicting Technology Adoption Behavior (pp. 544–562).

Sharma, G., & Singh, S. P. (2011). Economic Analysis of Post-harvest Losses in Marketing of Vegetables in Uttarakhand. *Agricultural Economics Research Review*, *24*(December), 309–315.

Singh, Vishal, Md. Hedayetullah, P. Z., and J. M. (2014). Postharvest Technology of Fruits and Vegetables : An Overview, Journal of post-harvest technology Postharvest Technology of Fruits and Vegetables : An Overview, (April).

Sivakumar, D., Jiang, Y., & Yahia, E. M. (2011). Maintaining mango (Mangifera indica L.) fruit quality during the export chain. *Food Research International*, *44*(5), 1254–1263. https://doi.org/10.1016/j.foodres.2010.11.022

Solanki, D. (2009). *A study on the adoption behavior of vegetable growers in relation to their socio-economic and psycho characteristics in Khandwa district of Madhya Pradesh*. R.A.K. College of Agriculture, Sehore.

Spector, P. E. (1992). *Summated Rating Scale Construction : An Introduction.*

Series: Quantitative Applications in the Social Sciences. Newsbury Park: Sage Publications Inc.

Stenmark, Å., Jensen, C., Quested, T., & Moates, G. (2016). *Estimates of European food waste levels*. *IVL-report C 186*. https://doi.org/10.13140/RG.2.1.4658.4721

Stuart, T. (2009). *Waste: Uncovering the global food scandal*. London, UK: Penguin.

Suzanna, P. (2016). Curbing Food wastage at Source. *New Straits Time*. Retrieved from https://www.nst.com.my/news/2016/06/151334/curbing-food-wastage-source

Teijlingen, E. R. Van. (2001). The importance of pilot studies, Social Research Update, Vol. 35 No, *35*.

Terano, R., Mohamed, Z., Shamsudin, M. N., & Latif, I. A. (2015). Factors influencing intention to adopt sustainable agriculture practices among paddy farmers in Kada, Malaysia. *Asian Journal of Agricultural Research*, *9*(5), 268–275. https://doi.org/10.3923/ajar.2015.268.275

The Sun Daily. (2014). Bumper crop leads to tomato glut in Cameron Highlands. 30 April 2014. Retrieved from: https://www.thesundaily.my/archive/1032978-IRARCH250438

Thomson, K. (2003). World agriculture: towards 2015/2030: an FAO perspective. *Land Use Policy*, *20*(4), 375. https://doi.org/10.1016/S0264-8377(03)00047-4

Tolly L and Kamtchouing P. (2016). Dynamics of Losses in Tomato Commodity Chain (Estimates based on experimental design in Cameroon)., (October), 546–551. https://doi.org/10.1481/icasVII.2016.b15e

Tröger, K., Hensel, O., & Bürkert, A. (2007). Conservation of Onion and Tomato in Niger - Assessment of Post-Harvest Losses and Drying Methods. *Tropentag 2007 University of Kassel-Witzenhausen and University of Göttingen , October 9-11, 2007*, (January 2014), 1–7.

Udas, S., Rai, B.K., Gurung, M., Thapa, R., Khatiwada, P. (2005). Assessment of postharvest handling systems of vegetables in the Eastern Hills of Nepal. *ISHS Acta Horticulturae*, *682*, 2191–2197.

UN. (2015). The World Population Prospects_ 2015 Revision _ Latest Major Publications - United Nations Department of Economic and Social Affairs.

Underhill, S. J. R., & Kumar, S. (2015). Quantifying postharvest losses along a commercial tomato supply chain in Fiji: A case study. *Journal of Applied Horticulture*.

United Nation. (2014). *World Urbanization Prospects*. New York: United Nation. https://doi.org/10.4054/DemRes.2005.12.9

USDA. (2009). Supermarket Loss Estimates for Fresh Fruit, Vegetables, Meat, Poultry, and Seafood and Their Use in the ERS Loss-Adjusted Food Availability Data Data / FoodConsumption Cataloging Record : *Economic Information Bulletin*, (44), 26.

Verghese, K., Lewis, H., Lockrey, S., & Williams, H. (2015). Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain. *Packaging Technology and Science*. https://doi.org/10.1002/pts.2127

Vlajic, J. V., Van Der Vorst, J. G. A. J., & Haijema, R. (2012). A framework for designing robust food supply chains. *International Journal of Production Economics*, *137*(1), 176–189. https://doi.org/10.1016/j.ijpe.2011.11.026

Wang, X. and Bagshaw, J. S. (2001). Postharvest handling systems assessment of pak choi and Chinese cabbage in Eastern-central China. *ACIAR Proceeding No. 105*, 22–25.

WEF. (2014). Enabling Trade: From Farm to Fork, (January).

Weinberger, Katinka; Genova II, Christian A.; Acedo Jr., A. L. (2008). Quantifying postharvest loss in vegetables along the supply chain in Vietnam, Cambodia, and Laos. *International Journal of Postharvest Technology and Innovation*, *1*, 288–297. https://doi.org/10.1504/IJPTI.2008.021463

WFLO. (2010). *Identification of Appropriate Postharvest Technologies for Improving Market Access and Incomes for Small Horticultural Farmers in Sub-Saharan Africa and South Asia.*

Wigati, L. P., & Darmawati, E. (2019, February). Losses and waste of tomato and red chilli along the supply chain. In *IOP Conference Series: Earth and Environmental Science* (Vol. 230, No. 1, p. 012001). IOP Publishing.

WMO. (2018). World weather information services- Cameron Highlands. Retrieved April 25, 2018, from http://worldweather.wmo.int/en/city.html?cityId=76

World Bank. (2011). Missing Food: The Case of postharvest Grain Losses in Sub-Saharan Africa., (56).

WRAP. (2008). *The food we waste* (Vol. 0).

WRAP. (2011). Reducing Food Waste through Retail Supply Chain Collaboration. *Oxon, UK: WRAP - Waste & Resources Action Programme*, (March), 44.

Yusoff, W. A., Jaafar, M., Kamarudin, M. K. A., & Toriman, M. E. (2015). Kajian penerokaan tanah dan perubahan kualiti air di tanah tinggi Lojing,

Kelantan, Malaysia. *Malaysian Journal of Analytical Sciences*, *19*(5), 951–959.

Zakaria, N. A., & Rahim, A. R. A. (2014). An overview of fruit supply chain in Malaysia. *Jurnal Mekanikal*, *37*(1).

Zakaria, A., and Mohamad. R. M. N. (2005). Chapter 8 Harvesting and postharvest handling. Organic vegetable cultivation in Malaysia. Malaysian Agricultural Research and Development Institute (MARDI). P147-160

Zanoni, S., & Zavanella, L. (2012). Chilled or frozen? Decision strategies for sustainable food supply chains. *International Journal of Production Economics*, *140*(2), 731–736. https://doi.org/10.1016/j.ijpe.2011.04.028

Zarim, A. (2016). Personal discussion with Head of Station, MARDI, Tanah Rata, Cameron Highlands.

Zheng, S., Wu, L., Gao, G.L., and Wu, P. (2001). Assessment of postharvest handling systems for vegetables in Beijing. *ACIAR Proceeding No. 105*, 17–21.

Zikmund, W. G. (2003). Research Methods.

Zulfiqar, M., Khan, D., Bashir, M. (2005). An assessment of marketing margins and physical losses at different stages of marketing channels for selected vegetable crops of Peshawar Valley.pdf. *Journal of Applied Sciences*, *5*(9), 1528–1532.