

University of Ghana <http://ugspace.ug.edu.gh>

**EFFECT OF DIFFERENT LOCAL EDIBLE COATINGS ON THE  
PHYSICAL, CHEMICAL AND ORGANOLEPTIC PROPERTIES OF  
CANARY YELLOW MELON (*Cucumis melo var. inodorus*)**

**BY**

**JEMILA MANBORAH AHMED WUNI**

**(10806142)**

**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA,  
LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR  
THE AWARD OF MPhil CROP SCIENCE DEGREE  
(POSTHARVEST TECHNOLOGY)**

**DEPARTMENT OF CROP SCIENCE**

**DECEMBER, 2021**

**INTEGRI PROCEDAMUS**

**DECLARATION**

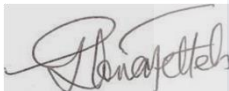
I, JEMILA MANBORAH AHMED WUNI, do hereby declare that except for references cited which have been duly acknowledged; this thesis “Influence of different local edible coatings on the physical, chemical and organoleptic properties of canary yellow melon (*Cucumis melo var. inodorus*) is the result of my own research. It has never been presented either in part or in whole for the award of any degree.



Jemila Manborah Ahmed Wuni (Student)

07/10/2022

Date



Dr. Gloria Essilfie (Main supervisor)

07/10/2022

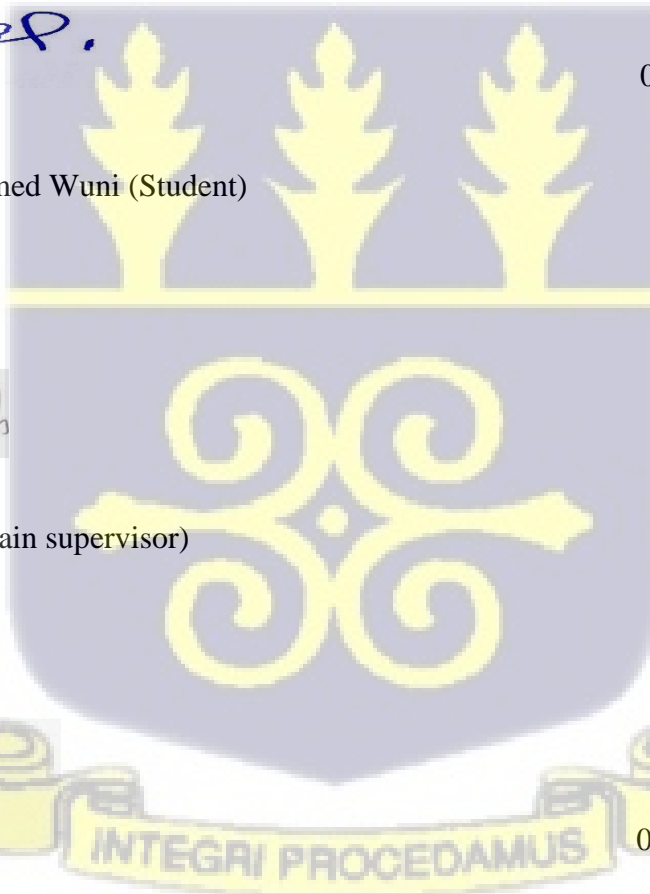
Date



Prof. John Oforu – Anim (Co-supervisor)

07/10/2022

Date



**DEDICATION**

This work is dedicated to the Glory of Almighty Allah. It is also dedicated to my parents and siblings for their prayers and support.



## ACKNOWLEDGEMENTS

First and foremost, my appreciation and thanks are for Allah, the Almighty, who inspired, energised and sustained me with good health and the right thoughts, ideas and positive mind to be able to produce this worthy product. Beyond this, my journey in this thesis would not have been possible without the support of many people, and they deserve acknowledgement. My appreciation and gratitude go to my supervisors Dr. (Mrs.) Gloria Essilfie and Prof. John Ofosu–Anim for their advice, suggestions, constructive comments, and guidance, without which this thesis would not have seen the light of day. Thank you so much for your priceless guidance. My gratitude equally goes to all the lecturers of the Department of Crop Science, College of Basic and Applied Sciences, University of Ghana, for their diverse roles in my solid training.

My appreciation also goes to Mr Bright Agbomadzi and Dr Nuhu Yidana for their support and personal advice, which contributed immensely to the success of this work. Special thanks go to all the Technicians at the Department of Crop Science, especially Mr Richard Otoo, for the immense assistance. I also say thank you to my colleagues in the programme for the bond of relationships and motivation as we journeyed together,

Everything has a foundation, and the foundation of this thesis could not have been possible without the indelible marks put on me by my parents, Alhaji Ahmed Wuni and Hajia Lelatu Adam. Your training, upbringing, encouragement, prayers, and investment produces this fruit, and I remain forever grateful. I also thank my husband, Mr S. S. Haruna and children, Arif, Akeelah, Haarun, and Sujuud for enduring my shared time with them and this thesis. For all those who played varied roles in bringing this to an end, I say thank you immensely.

### LIST OF ABBREVIATIONS

F.A.O.	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
CFCG	Chefs for Change Ghana Foundation
ITIS	Integrated Taxonomic Information System
SSA	Sub-Saharan Africa
RTC	Ready to Cook
TA	Titrateable Acids
TSS	Total Soluble solids
Ctrl	Control (no coating)
SB	Shea Butter
NO	Neem Oil
BW	Beeswax
SB + BW	Shea Butter + Beeswax
SB + NO	Shea Butter + Neem Oil
NO + BW	Neem Oil + Beeswax
SB + BW+NO	Shea Butter + Beeswax + Neem Oil
%WL	Percentage Weight Loss
JSS	Junior Secondary School
JHS	Junior High School.
AEA	Agricultural Extension Agent



## ABSTRACT

Melon has high export potential but is highly perishable. To meet the consumer's desire to eat melons free of chemicals and also extend the shelf life of the fruit, handlers along the value chain generally employ various postharvest practices to achieve positive results. This study sought to assess the influence of different local edible coatings on the physical, chemical, and organoleptic properties of canary yellow melon (*Cucumis melo var. inodorus*). The study was carried out in two phases -a survey involving farmers and traders and a laboratory analysis. In the first phase, postharvest handling practices along the yellow melon value chain in Afiemya - Prampram District of Ghana was assessed. One hundred open-ended and close-ended questionnaires were administered to farmers and traders of yellow melon. For the second phase, the influence of different local edible coatings on the physical, chemical, and organoleptic properties of canary yellow melon were assessed. Eight (8) treatments were laid out in Completely Randomized Design (CRD) with three replications of 18 fruits per treatment. Seven waxing materials (Shea Butter, Neem Oil, Beeswax, Shea Butter + Beeswax, Shea Butter + Neem Oil, Neem Oil + Beeswax, Shea Butter + Beeswax + Neem Oil) were used for coating the yellow melon fruits. Treated fruits plus control fruits were kept at ambient condition (29.3–31.3 °C, 69.0–72.0% RH) till 21 days and assessed for various quality indices including weight loss, firmness, pH, total soluble solids (TSS), total titratable acids (TTA), vitamin C and shelf-life. Results obtained from phase I of the study showed that farmers ensured that there were available markets before the fruits were planted and even harvested. The majority of the farmers had access to extension services but the services rendered did not include postharvest technology. Postharvest losses were recorded throughout the value chain of the fruit. Some of the losses recorded were mechanical, physiological, and biological (rot and pest attack). Notably, 66% mechanical loss at harvest was reported by the respondents. At the sale point, 82% of traders recorded losses and the rate of spoilage was up to 98%. The total economic loss incurred by the farmers was estimated at GH¢ 17, 500 out of an expected income of GH¢ 80,000. While that of the traders was GH¢ 4,300 out of an expected income of GH¢ 15,000. Lack of appropriate vehicles for the transportation of fruits, lack of storage facilities and postharvest technology were among the challenges the handlers of the fruit faced. Respondents did not have any knowledge about waxing and did not know of any modern storage technology but were willing to adopt storage technologies. Results from the laboratory analysis indicated that all coated treatments were able to preserve fruits' quality indices during the

storage period. Longer shelf-life was observed in fruits coated with BW (18 days) while the shortest shelf-life of nine days was recorded for the control (uncoated fruits). Fruits coated with BW, SB and BW and its combination maintain fruit firmness and also reduce percentage weight loss. Fruits coated with BW and SB + NO recorded lower Vitamin C loss. Sensory evaluation revealed the overall acceptability of waxed fruits and consumers' willingness to purchase waxed fruits. BW can therefore be used to prolong the shelf-life, improve glossiness and attractiveness, ensure firmness and also reduce weight loss of yellow melon fruits. Regarding the pathogenicity of organisms associated with postharvest rot of melon fruits, the results showed that the pathogen that causes yellow melon rot is *Lasiodiplodia theobromae*. The pathogenic ability of the organism proved positive as it was able to cause decay and reduced the shelf-life when inoculated onto healthy fresh samples of the fruits causing postharvest losses. The symptoms that appeared on the diseased fruit made it both unmarketable and unwholesome for household use, therefore, causing financial and economic losses to both farmers and traders. The study made a number of recommendations to help reduced or curbed postharvest losses. First, an agreement between farmers and buyers before planting or harvesting should be documented to avoid future disappointment that will lead to losses. Along the value chain (harvesting, sorting, packaging, transportation, and storage) general care should be considered during fruit handling. Best results can be achieved when baskets are cushioned with soft material to reduce impact during handling and transportation, throwing fruits into baskets and overloaded should be avoided to reduce bruises, which result in losses. The presence of specialized temperature control vehicles and storage facilities can significantly reduce post-harvest losses. The use of black polythene sheets, nylon sacks, and tarpaulin for covering fruits during transportation and storage should be avoided to prevent the build-up of heat that will accelerate postharvest losses. Extension workers should include postharvest services to farmers and other food handlers to preserve the quality of the fruits and also reduce losses. Researchers should disseminate new postharvest findings to extension workers to enable them to carry out their services efficiently. Therefore, it is recommended that BW and its combination should be used to treat yellow melon fruits to prolong their shelf life and also preserve their physical, chemical, and organoleptic properties.

## TABLE OF CONTENT

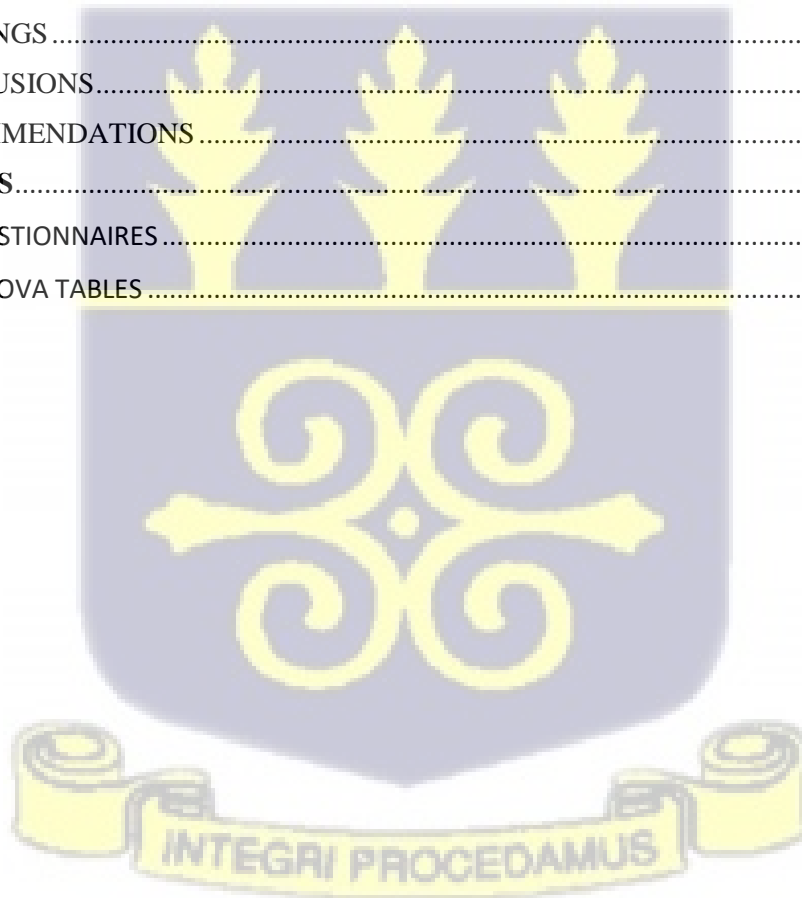
<b>DECLARATION</b> .....	i
<b>DEDICATION</b> .....	ii
<b>ACKNOWLEDGEMENTS</b> .....	iii
<b>LIST OF ABBREVIATIONS</b> .....	iv
<b>ABSTRACT</b> .....	v
<b>TABLE OF CONTENT</b> .....	<b>Error! Bookmark not defined.</b>
<b>LIST OF TABLES</b> .....	xii
<b>CHAPTER ONE</b> .....	<b>1</b>
<b>1.0 INTRODUCTION</b> .....	<b>1</b>
1.1 Background .....	1
1.2 Problem Statement .....	1
1.3 Justification.....	2
1.4.1 Main Objective.....	3
<b>CHAPTER TWO</b> .....	<b>4</b>
<b>2.0 LITERATURE REVIEW</b> .....	<b>4</b>
2.1.0 Botany of Melon, Its Uses and Health Benefits .....	4
2.1.1 Botany of Melon .....	4
2.1.2 Uses of Melon .....	5
2.1.3 Health Benefits of Melon.....	5
2.2 The World Production of Melons .....	6
2.3 Postharvest Losses of Melon.....	7
2.4.0 Causes of Postharvest Losses along the Yellow Melon Value Chain.....	8
2.4.1 Poor Harvesting Practices .....	8
2.4.2 Mechanical Damage.....	9
2.4.3 Pathological / Microbiological Damage.....	10
2.4.4 Environmental Conditions .....	11
2.4.5 Physiological Damage.....	12
2.5.0 Postharvest Management Practices that Reduces Losses.....	13
2.5.1 Harvesting .....	13
2.5.2 Pre-cooling.....	14
2.5.3 Cleaning, Disinfecting and Trimming.....	15
2.5.4 Packaging.....	15

2.5.5 Storage .....	17
2.5.6 Transportation .....	18
2.5.7 Marketing .....	18
2.5.8 Processing and Value Addition.....	19
2.6.0 Influence of Local Edible Coating Materials on the Physico – Chemical and Organoleptic Properties of Melon Fruits .....	20
2.6.1 Edible Coating .....	20
2.6.2 Edible Coating and its Influence on the Physico – Chemical Characteristics of Fruits .....	22
2.6.3 Influence of Edible Coating on Total Soluble Solids (°Brix). .....	23
2.6.4 Influence of Edible Coating on Vitamin C .....	24
2.6.5 Influence of Edible Coating on Total Titrable Acids.....	25
2.6.6 Influence of Edible Coating on Firmness.....	27
2.6.7 Influence of Edible Coating on pH .....	28
2.6.8 Influence of Edible Coating on Weight Loss.....	30
2.6.9 Influence of Edible Coating Pathogens.....	32
2.7 Organisms Associated with Postharvest Rot of Melon Fruits .....	33
2.8 Pathogenicity of Yellow Melon Fruit Rot.....	35
<b>CHAPTER THREE.....</b>	<b>37</b>
<b>3.0 MATERIALS AND METHODS .....</b>	<b>37</b>
3.1 Introduction.....	37
3.2 Study Area .....	37
3.3.0 Assessing the Postharvest Management Practices along the Yellow.....	37
3.3.1 Sampling Size and Method .....	37
3.4.0 Laboratory Assessment of Changes in Quality Yellow Melon fruits treated with different waxing materials.....	38
3.4.1 Source of Samples and Waxing Materials Used .....	38
3.4.2 Sample Preparation, Wax Application and Storage .....	38
3.4.3 Shea Butter Wax .....	39
3.4.4 Neem Oil Wax .....	39
3.4.5 Beeswax .....	39
3.4.6 Shea Butter + Beeswax .....	39
3.4.7 Shea Butter + Neem Oil Wax .....	40
3.4.8 Neem Oil + Beeswax .....	40
3.4.9 Shea Butter + Beeswax + Neem oil .....	40
3.4.10 Description of Experimental Treatments .....	41

3.5.0 Data Collection .....	42
3.5.1 Percentage Weight Loss (% WL) Determination.....	42
3.5.2 Fruit Firmness (FF) Determination .....	43
3.5.3 Total Soluble Solids Determination (TSS) .....	43
3.5.4 Titratable Acidity Determination (TTA).....	43
3.5.5 pH Value Determination .....	44
3.5.6 Dye standardization.....	44
3.5.7 Vitamin C Determination.....	45
3.5.8 Shelf-Life Determination (SL).....	45
3.6 Sensory Evaluation of yellow melon fruits.....	46
3.7.0 Isolation and Identification of Pathogen Associated with Yellow Melon ( <i>Cucumis melo</i> ) Rot. ...	46
3.7.1 Preparation of Potato Dextrose Agar (P.D.A).....	46
3.7.2 Isolation of Pathogens .....	46
3.7.3 Identification of Pathogens .....	47
3.8 Pathogenicity of yellow Melon Rot .....	48
3.9 Data Analysis .....	48
<b>CHAPTER FOUR.....</b>	<b>49</b>
<b>4.0 RESULTS.....</b>	<b>49</b>
4.1.1 Gender of Respondents .....	49
Figure 4.1 Gender of respondents .....	49
4.1.2 Educational Level of Respondents .....	49
Figure 4.2 Educational level of respondents .....	50
4.2.0 Post-Harvest Handling Practices along the Yellow Melon Value Chain in Afienya.....	50
4.2.1 Stage of Harvest of Yellow Melon Fruit.....	53
4.2.2 Packaging Material .....	53
4.2.3 Transportation .....	54
4.2.3.1 Vehicle Used.....	54
4.2.3.2 Materials for Covering the Fruits during Transportation.....	55
4.2.4.0 Storage Practices .....	56
4.2.4.1 Where Farmers Store Fruits when there is no Market.....	56
4.2.4.2 Storage Description.....	56
4.2.4.3 Where Traders Store Fruits.....	57
4.2.4.4 How Traders Store Their Fruits .....	58
4.2.4.5 Challenges Traders Face during Storage.....	58

4.2.5 Period of Trading.....	59
4.2.6.0 Post-Harvest Losses .....	60
4.2.6.1 Types of Losses Incurred during Harvesting and Packaging .....	60
4.2.6.2 Where Most Losses Occurred during Trading .....	61
4.2.6.3 Rate of Spoilage .....	61
4.2.7 Estimate of losses Along the Value Chain of Yellow Melon .....	62
4.2.8 Respondents Knowledge on Waxing Materials, Modern Post-Harvest Technology and Wiliness to Adopt Innovative Post-Harvest Technology.....	63
4.2.9 Help from Agricultural Extension Agents (AEAs) .....	63
4.2.10 Nature and Type of Service from AEAs.....	64
4.2.11 Effect of the Different Waxing Materials on the Physico – Chemical.....	65
Attributes of Yellow Melon Fruits.....	65
Table 4.2. Effect of waxing materials on percentage weight loss of yellow melon fruits and days of storage.....	66
4.2.18 Effect of Different Waxing Material on the Sensory Attributes Of Yellow Melon Fruits .....	73
4.2.28 Effect of Edible Coatings on the Shelf-life of Yellow Melon Fruits .....	83
4.2.29 Organisms Identified after Isolation.....	83
4.2.30 Pathogenicity Test.....	84
<b>CHAPTER FIVE.....</b>	<b>86</b>
<b>5.0 DISCUSSION .....</b>	<b>86</b>
5.2 Educational Level of Respondents.....	86
5.3.0 Postharvest Handling Practices along the Yellow Melon Value Chain in Afiinya .....	87
5.3.1 Pre-Arrangement for Market.....	87
5.3.2 Stage of harvest of Yellow Melon Fruit.....	88
5.3.3 Packaging Material .....	88
5.3.4.0Transportation of Fruits .....	89
5.3.4.1 Vehicle Used.....	89
5.3.4.2 Materials for Covering the Fruits during Transportation.....	90
5.3.5.0 Storage Practices.....	90
5.3.5.1 Where Traders Store Fruits and Challenges Faced .....	91
5.3.6.0 Postharvest Losses .....	91
5.3.6.1 Types of Losses Incurred .....	92
5.3.6.2 Where Most Losses Occurred during Trading .....	92
5.3.7 Estimate of Losses .....	93

5.4.0 Help from Agricultural Extension Agents (AEAs) and Nature of Service .....	93
5.5.0 Effect of Waxing on the Quality Changes of Yellow Melon Fruit .....	94
Percentage Weight Loss (% WL).....	94
5.5.1 Firmness.....	94
5.5.2 Total Soluble Solids (TSS) or % Brix.....	95
5.5.3 Titratable Acidity.....	96
5.5.5 pH.....	98
5.5.6 Shelf-Life.....	99
5.5.7 Sensory Evaluation.....	99
5.5.8 Pathogen Identified and Pathogenicity Studies.....	100
<b>CHAPTER SIX.....</b>	<b>101</b>
<b>6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>101</b>
6.1 SUMMARY.....	101
6.2.0 FINDINGS.....	102
6.3 CONCLUSIONS.....	103
6.4 RECOMMENDATIONS.....	104
<b>REFERENCES.....</b>	<b>107</b>
APPENDIX 1: QUESTIONNAIRES.....	151
APPENDIX 2: ANOVA TABLES.....	161



## LIST OF TABLES

Table 4.1 Estimate of losses along the value chain of yellow melon.....	68
Table 4.2 Effect of waxing materials on percentage weight loss of yellow melon fruits and days of storage.....	71
Table 4.3 Effect of waxing materials on the firmness of yellow melon fruits. ....	73
Table 4.4 Effect of waxing materials on pH of yellow melon fruits.....	74
Table 4. 5 Effect of waxing materials on total soluble solids (TSS) of yellow melon fruits. ....	76
Table 4.6 Effect of waxing materials on total titratable acidity of yellow melon fruits. ....	77
Table 4.7 Effect of waxing materials on Vitamin C content of yellow melon fruits. ....	78
Table 4.8 Effect of waxing materials on the skin colour of yellow melon fruits. ....	79
Table 4.9 Effect of waxing materials on the texture of yellow melon fruits.....	81
Table 4.10 Effect of waxing materials on the taste of yellow melon fruits. ....	82
Table 4.11 Effect of waxing materials on pulp colour of yellow melon fruits. ....	83
Table 4.12 Effect of waxing materials on mouth feel of yellow melon fruits. ....	84
Table 4.13 Effect of waxing materials on the glossiness of rind of yellow melon fruits. ....	85
Table 4.14 Effect of waxing materials on the flavour of yellow melon fruits. ....	86
Table 4.15 Effect of waxing materials on the attractiveness of rind of yellow melon fruits. ....	87
Table 4.16 Effect of waxing materials on overall acceptability of yellow melon fruits. ....	88

**LIST OF FIGURES**

Figure 4.1 Gender of respondents ..... 53

Figure 4.2. Educational level of respondents ..... 54

Figure 4.3 Stage of yellow melon fruit at harvest .....57

Figure 4.4 Vehicle used ..... 59

Figure 4.5 Materials for covering the fruits during transportation ..... 60

Figure 4.6 Storage description ..... 61

Figure 4.7 How traders store their fruits ..... 63

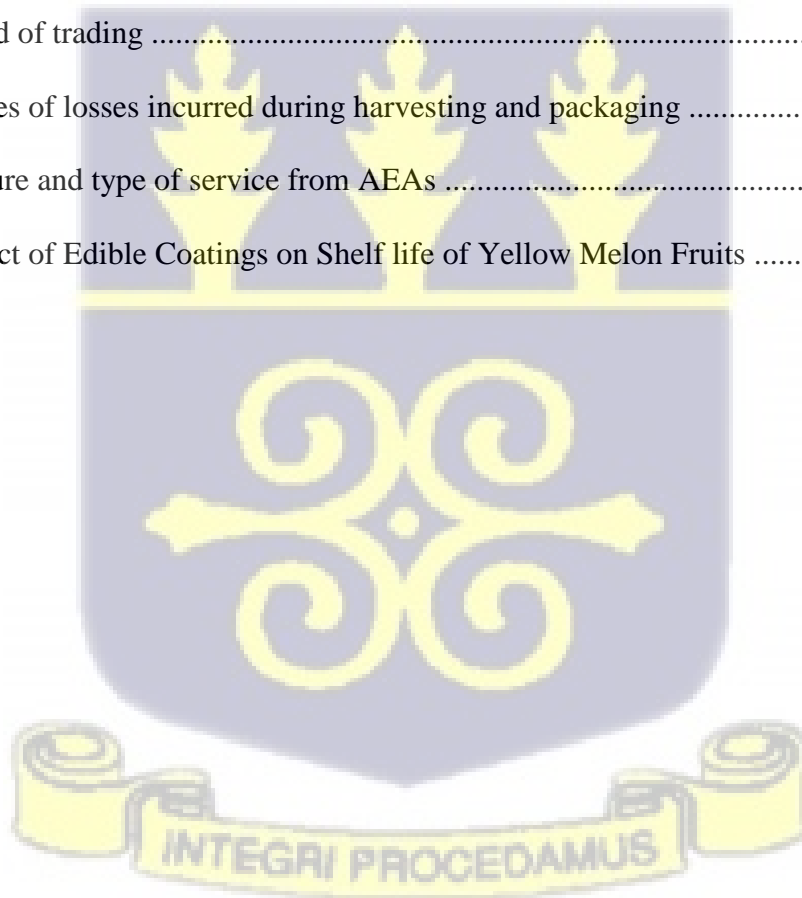
Figure 4.8 Challenges traders face during storage ..... 64

Figure 4.9 Period of trading ..... 65

Figure 4.10 Types of losses incurred during harvesting and packaging ..... 66

Figure 4.11 Nature and type of service from AEAs ..... 70

Figure 4.12 Effect of Edible Coatings on Shelf life of Yellow Melon Fruits ..... 89



## LIST OF PLATES

Plate A. Harvesting of yellow melon .....	57
Plate B. Sorting and cleaning of yellow melon .....	57
Plate C. Retailing yellow melon at market.....	57
Plate D. Storage of yellow melon at market.....	57
Plate E. White to mouse gray mycelium growth on PDA.....	93
Plate F. Dark colonies growth on PDA.....	93
Plate G. Irregular grey pycnidia .....	93



## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background

Melon (*Cucumis melo L.*) is a Cucurbitaceous fruit and is in the same family as watermelons (*Citrullus lanatus*), calabash (*Lagenaria sileraria*), cucumbers (*Cucumis sativus*), pumpkins (*Cucurbita pepo*), and butternut squash (*Cucurbita pepo*) (Ong'ute, 2019). Melon fruit is among the most extensively consumed fruits in the world (Mallek-Ayadi *et al.*, 2017), and it is the world's fifth-most-produced (31,166,896 t) fruit (Ortiz-Duarte *et al.*, 2019). China produces 40% of the world's total quantity (Luo *et al.*, 2018).

Globally, melon is considered an important crop because its fruits are highly loved and prized (Esteras *et al.*, 2020). The crop can adapt to different types of soils and climate (Rolim *et al.*, 2020). High yields are recorded in regions with warm and hot climate, making melons popular in areas where other crops struggle to thrive (Aldoshin *et al.*, 2020). Ghana has great potential to produce and export high-quality melons.

In Ghana, agriculture contributes to the socio-economic advancement of the country, but the sector is faced with unprecedented challenges that affect the actual degree of agricultural worth to development. Prominent among the challenges is postharvest losses of various food crops. Loses are recorded at all phases of the supply and handling chain (Yahia *et al.*, 2019).

#### 1.2 Problem Statement

According to a report by the Chefs for Change Ghana Foundation – CFCG (General News, 2017) in Ghana, over 45 % of uneaten food worth more than six billion dollars ends up rotting in landfills, and these losses and waste are tracked throughout the food supply chain. Futukpor

reported that, farming in Ghana has become unattractive due to postharvest losses with annual losses estimated at \$700,000 ([Ghana News Agency](#), 2017).

According to Kitinoja *et al.*, (2011), postharvest losses of horticulture crops are estimated to be between 30-80% in Ghana and this includes melons. Since melons have a short ripening period, high sugar and water content, and require long-distance transportation, they are prone to significant postharvest loss. In addition, pathogenic fungus such *Alternaria alternata* and *Fusarium semitectum* have also been implicated for up to 30% of melon postharvest losses (Chen *et al.*, 2015).

In Ghana one food crop which has not benefitted greatly from investigation in respect of postharvest handling is melon.

### 1.3 Justification

Food crops, particularly horticultural crops, are seasonal and perishable leading to significant losses after harvest. To reduce post-harvest losses and extend the shelf-life, farmers, industry, and consumers employ diverse specialized post-harvest handling practices and treatments. Post-harvest treatments (physical, chemical, and gaseous) at the appropriate storage temperature can maintain harvested produce freshness and quality to keep fresh produce safety standards (Mahajan *et al.*, 2014).

Edible coating is one of the physical post-harvest treatments that has been demonstrated to be effective in preserving the quality of fruits (Guimarães *et al.*, 2018). They act as a partial barrier to moisture movement on the surface of the produce, therefore reducing moisture loss during post-harvest storage. It also forms a modified atmosphere around the product to slow respiration, senescence, and enzymatic oxidation and also preserve colour and texture, and retains volatile

compounds that contribute to natural aroma, and restrict foreign odours. It has been identified to maintain fresh produce structural integrity and protect fruits against mechanical damages.

This study therefore sought to contribute toward finding lasting measures that would be capable of assisting farmers and traders to effectively minimize the perennial losses of melon.

#### **1.4.0 Objectives of the Study**

##### **1.4.1 Main Objective**

The main objective of the study was to assess the effectiveness of different edible waxing materials in preserving the quality and shelf-life of melon fruits stored under tropical ambient conditions (30–32°C and 60–72% RH).

##### **1.4.2 Specific Objectives**

The study specifically seeks to address the following objectives:

1. To assess postharvest handling practices along the melon value chain in Afienea – Prampram District.
2. To evaluate the extent to which different local edible coating materials can preserve the physico-chemical and organoleptic quality attributes of melon fruits in the AfieneaPrampram District of the Greater Accra Region of Ghana.
3. To isolate, identify and evaluate the pathogenicity of organisms associated with postharvest rot of melon fruits.

## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1.0 Botany of Melon, Its Uses and Health Benefits

##### 2.1.1 Botany of Melon

Melon (*Cucumis melo L.*) is one of the 825 species in the *Cucurbitaceae* family (ITIS, 2017; Vishwakarma *et al.*, 2017). Macêdo *et al.*, (2017) and Tadmor *et al.*, (2010), identified tropical Africa as the origin of melon, whereas Sebastian *et al.* (2010) and John *et al.* (2013) reported that it has its root in Asia. Its wild relatives are distributed in Asia, Africa, and Australia (Luan *et al.*, 2008; Kerje and Grum, 2000; Sebastian *et al.*, 2010; Endl *et al.*, 2018).

Pitrat *et al.* (2000) classified melons into seven groups, of which four are sweet melons and three are non-sweet or high acid melon. The sweet melons are cantalupensis (European cantaloupe), reticulatus (U.S. net muskmelon), inodorus (casaba, honeydew, Piel de sapo and yellow canary), and makuwa. The three non-sweet or high-acid melons are flexuosus (snake melon), dudaim (pome-granate melon) and conomon.

The crop is a herbaceous annual plant with long trailing vines, woody rootstock, and a short angled stem that is bristly-haired. The leaves are simple, very hairy, and have a diameter of about 7-15 cm. On the same plant, female and male flowers can grow. They sometimes grow hermaphrodite flowers too. At least 65% of the total weight of melon is accounted for by the fruit, of which 25% and 7% are accounted for by peels and seeds, respectively (Fundo *et al.*, 2018). Depending on the type and cultivar, the fruit differs in size and shape; the texture of the skin varies from smooth to

sutured or netted, the rind colours range from white, green, to yellow-toned, the internal flesh is usually green or orange in colour, but pink and white are also common

(Kyriacou *et al.*, 2018). The seeds which are usually between 0.4cm and 1.1cm long and 0.2cm-0.3cm wide, are small, light brown and smooth (Ajuru & Okoli, 2013). Melon crops thrive in fertile, well-drained soil with a pH of 6.0 to 6.5 and temperatures ranging from 18 °C to 35°C (Kemble, 2014).

### **2.1.2 Uses of Melon**

Melons are primarily grown as vegetables. The fruits are the most widely consumed component of the plant, but seeds, flowers, tendrils, very young shoots, and roots are often also consumed (Nuñez-Paleniús *et al.*, 2008). Apart from immature melons use in salads, cooked or pickled, they are also enjoyed when stuffed with meat, rice and spices, and fried in oil. Mature fruits are consumed fresh as a dessert fruit, canned, or processed into syrup or jam (Ajuru & Nmom, 2017). Ice cream or a refreshing drink are also made out of the fruit by combining the pulp with water, sugar or sometimes with milk (Adamu *et al.*, 2017). The seeds are known to contain unsaturated vegetable oil and protein and can be lightly roasted and eaten like nuts (McCreight *et al.*, 1993).

### **2.1.3 Health Benefits of Melon**

The cultivar, environmental condition and fruit maturity stage influence the chemical composition of melon fruit (Burger *et al.*, 2006; Maietti *et al.*, 2012). The growing interest in the consumption of melon can be attributed to its excellent flavour, rich nutritional and bioactive properties (Petkova & Antova, 2015). Vitamins B6, pro-vitamin A, and C, as well as riboflavin, thiamine, and folic acid, are all present in melon fruit (Saeed *et al.*, 2019).

It is a sweet and juicy fruit loaded with nutritional and bioactive properties (Vishwakarma *et al.*, 2017). Its consumption is increasing as a result of its potential health benefits. These include high antioxidant and anti-inflammatory properties (Vouldoukis *et al.*, 2004; Ismail *et al.*, 2010), anti-diabetic benefits (Jayasooriya *et al.*, 2000; Kenny *et al.*, 2013), as well as its use in traditional medicine throughout the world (Subratty *et al.*, 2005; Semiz & Sen, 2007; Wu & Ng, 2008; Mahomoodally, 2013).

Melon fruits are reported to exhibit medicinal properties (Dhiman *et al.*, 2012). Extensive work on the melon has shown that its extracts exhibit anti-oxidative (Egoumenides *et al.*, 2018), antiinflammatory (Ezzat *et al.*, 2019), anti-diabetes (Lee *et al.*, 2018), and anti-cholesterol (Shankar *et al.*, 2015) properties.

Polyphenol levels in melon fruit are extremely high (Ullah *et al.*, 2014). The high levels of polyphenols and carotenoids are primarily responsible for the melon fruit's antioxidant function. Because of their antioxidant activity against free radicals, carotenoids, particularly  $\beta$ -carotene, have been recognized, suggesting protective roles for reducing the risk of certain cancers and cardiovascular diseases (Henan *et al.*, 2016; Vishwakarma *et al.*, 2017). Rodríguez-Pérez *et al.* (2013) also found polyphenol compounds beneficial to the cardiovascular system. According to Vishwakarma *et al.* (2017), *C. melo* has been identified traditionally as an effective anti-parasitic agent (anthelmintic or vermifuge).

## 2.2 The World Production of Melons

According to FAOSTAT (2019), 32 million tons of melon were estimated to be produced globally in 2017, thus double the quantity produced in 1993. China, followed by Turkey, Iran, the United States of America and Spain, are the world's leading producers of sweet melons, respectively

(Muhammad and Masdek, 2016). Among all the fruits in the United States, melons are one of the most consumed. The average American consumes approximately 13 kg of melon annually (Agricultural Marketing Resource Center, 2018). Melon is cultivated on all continents and covers 1.22 million hectares of fields, growing 31.48 million tons each year (De Macêdo *et al.*, 2019; Freitas *et al.*, 2009; Damiani, 2003). In Brazil, the crop is of major economic significance as it generates jobs and income (De Macêdo *et al.*, 2019; Freitas *et al.*, 2009; Damiani, 2003).

### 2.3 Postharvest Losses of Melon

Postharvest losses are measurable losses of a food crop that occur between the times of harvest to the time of consumption (Sawicka, 2019). Before the consumption of food crops, postharvest losses are recorded along the value chain from farm to fork (Beune, 2018). Harvesting, drying, winnowing, washing, storage (on-farm, retailer, home), preparation of meals and consumption are all phases where losses can occur (Sheahan & Barrett, 2017). The losses can be quantitative and qualitative (Shee *et al.*, 2019).

When the physical volume of food is reduced through time and space it is termed as quantitative loss, whereas losses that affect the nutrients, visual aesthetic appeal, or food breakage or contamination is referred to as qualitative losses (Sheahan & Barrett, 2017).

Horticulture crops are perishable because of their high moisture content, making them more vulnerable to shrivelling and mechanical damage. Fruits, vegetables, and root crops thrive on their stored food stores after harvesting. As food and water supplies decrease, produce dies and decays resulting in losses. Farmers cultivating these perishable crops are faced with high economic loss because of lack of appropriate methods to extend the shelf life of these crops (Banjaw, 2017). Azene *et al.*, (2014) argued that the supply and consumption of horticulture crops is likely to drop

in urban areas due to farmers' fear of cultivating perishable crops that are susceptible to postharvest losses. It is therefore important that post-harvest handling systems are employed to ensure that harvested fruits and vegetables meet consumers' expectations (Ahmad & Siddiqui, 2015).

The worrying impact of postharvest losses are especially significant in sub-Saharan Africa (SSA). In particular, not only is agricultural productivity low, but about 374 million people face severe food insecurity (FAO 2018). In Ghana, about 20–50% of vegetables generated are estimated to be lost due to preharvest and post-harvest factors, including cultural practices (e.g., fertilisation, water supply, and harvesting method) and poor post-harvest handling (Sánchez-González *et al.*, 2016; Isaac *et al.*, 2015). The unprecedented rise in food imports in Nigeria is triggered by over 40 % post-harvest losses (Cortbaoui, 2013). Ahmed, (2013) reported that farmers in Nigeria are poorer due to postharvest losses.

## **2.4.0 Causes of Postharvest Losses along the Yellow Melon Value Chain**

### **2.4.1 Poor Harvesting Practices**

Harvesting marks the end of the production cycle, indicating that the food is ready for consumption, sale, or storage. It entails separating food crops (fruits, vegetables, and root crops) from their parents.

The storage life and final quality of fruits and vegetables are influenced by maturity at harvest time. Immature produce is prone to shrivelling and mechanical injury (Ramjan & Ansari, 2018). Ripening at harvest time also plays a vital role in determining product quality and shelf-life. When fruits are harvested at the unripe stage, the acidic level rises while the sugar level becomes low

when finally ripen. Overripe fruits, on the other hand, have a shorter shelf-life. The nutritional and economic value of fruits are also affected negatively when harvested early resulting in rejection (ömer, 2018; Kader, 1996).

According to Ramjan & Ansari, (2018) and Ars, (2014), harvest time can have an impact on size, flavour, tenderness, texture and colour. For instance, melon must achieve an appropriate sugar content before harvesting, while snap beans must reach a certain sieve size, summer squash and cucumbers must be harvested within a narrow size range. The ideal time for harvesting tomatoes meant for shipment is “mature green” or “breaker” and not the post “pink stages”. Tomatoes for direct sales can be harvested when ripe. Cabbage, winter squash, pumpkin, peppers have a wider window for harvesting.

Harvesting can be done manually or mechanically. Harvesting methods can result in losses (Kasso & Bekele, 2016). The method chosen if not carried out properly can lead to mechanical injuries such as bruises, surface abrasions and cuts. These injuries can accelerate the loss of water and vitamin C in horticultural crops, resulting in increased susceptibility to decay-causing pathogens (Ramjan & Ansari, 2018).

The use of unhealthy, poorly designed, inadequately maintained and unsuitable containers for collecting and transporting fresh produce can result in significant post-harvest losses. Buckets, sacks, baskets, and boxes are some of the most regularly used containers (Yahaya *et al.*, 2019).

#### **2.4.2 Mechanical Damage**

Fruit mechanical damage such as bruises, cuts, punctures, split and abrasion occurs when food crops are not properly handled during harvesting, grading, packaging and transport resulting in

structural, tissue and cell damage to fruits (Li & Thomas, 2014). The most prevalent type of mechanical damage that can happen during postharvest handling is bruising (Ahmadi *et al.*, 2010; Tabatabaekolour, 2013). Bruises occur when an excessive amount of external force acts on the surface of the fruit against a rigid body or fruit against fruit (Li & Thomas, 2014; Stropek & Gołacki, 2015). Physiological activities such as respiration and moisture loss are accelerated when bruises are present on freshly harvested food crops. The wounds on the skin serve as an exit for essential chemical composition and an entry for pathogens (Kumar *et al.*, 2016). According to (Lü & Tang, 2012), mechanical injuries speed up fruit fermentation, deterioration and cross-contamination during storage.

Defects and disorders as a result of mechanical injury have a significant impact on consumer choice of fruits (Jaeger *et al.*, 2016). These undesirable qualities affect both the internal and outward appearance of the fruit. The undesired outward look of the fruit lowers consumers' sensory and hedonic expectations, therefore contributing to downgrading or rejection (Hooge *et al.*, 2011).

### **2.4.3 Pathological / Microbiological Damage**

During postharvest handling, distribution, and storage, pathological infections cause significant deterioration and shorten the shelf-life of fruits and vegetables (Dukare *et al.*, 2019). The majority of the losses are recorded during storage, with mould and bacterial being the main causal agents (Bourne 1977; Buchholz *et al.*, 2018; Padmaperuma *et al.*, 2020).

According to Singh & Sharma (2018), most of these organisms are weak pathogens and can only gain entry for infection through mechanical injuries (such as fingernail scratches and abrasions, rough handling, insect punctures, and cut stems) or natural openings (cuticle or stomata, lenticels).

Each year, rot diseases caused by fungal pathogens cause significant agricultural and horticultural crop losses (Mahmoud, 2005; Parveen *et al.*, 2016). Products can be contaminated with mycotoxins as a result of fungal proliferation (Wu *et al.*, 2014).

Mallek-Ayadi *et al.* (2017) reported that, during postharvest handling, the likelihood of rapid pathological growth and infectious fruit symptoms are influenced by environmental factors such as temperature, moisture, and air composition (particularly O<sub>2</sub> and CO<sub>2</sub> concentrations).

#### 2.4.4 Environmental Conditions

The postharvest life of fresh fruits and vegetables is determined by environmental factors such as temperature, humidity, composition and percentage of gases under controlled atmospheric storage (Yahiya *et al.*, 2019). Fresh food releases more ethylene at high temperatures, which speeds up respiration and the metabolic processes while, low temperature affects the maturing process of fruits by preventing the generation of ethylene that acts as a plant hormone that promotes respiration (Liu, 2014). Increased depletion of respiration substrates and moisture diffusion across the product peel is facilitated by high temperatures (Caleb *et al.*, 2013; Xanthopoulos *et al.*, 2017; Bovi *et al.*, 2018). Localized bleaching, sunburns and sunscalds can occur in fruits when temperatures are high due to sunlight, whereas very low temperatures result in chilling injury in horticultural crops which enable the microbial attack. Some of the symptoms observed during this period include failure to ripe, pitting, surface and internal discolouration, and off-flavours (Kader, 2013).

Small-scale farmers typically store their fresh product at lower relative humidity levels than recommended, resulting in moisture loss (Singh *et al.*, 2014). Moisture loss of up to 3-6% in fruits and vegetables show symptoms such as wilting, shrivelling and dryness (Nunes *et al.*, 2009;

Olorunnisola & Okanlawon, 2017). These changes have an impact on a product's marketability or economic value, especially if fruits and vegetables are sold by weight (Yahia *et al.*, 2011).

Relative humidity also influences the uniformity of fruit ripening, the onset of decay, the occurrence and severity of specific physiological disorders, and the loss of some water-soluble components from the commodity, such as vitamin C (Yahia *et al.*, 2011). Moisture condensation on fruit surfaces can occur when the relative humidity is very high, this creates ideal conditions for the proliferation of microbial growth, which leads to fruit rot (Ben-Yehoshua *et al.*, 1996; Lufu *et al.*, 2017).

#### **2.4.5 Physiological Damage**

Horticultural crops are susceptible to postharvest physiological disorders. These disorders account for up to 50% of postharvest losses depending on the crop quality, harvest method, time of storage, and shelving conditions (Dias *et al.*, 2020). Depending on the nature of the produce, mass loss of these produce can be caused by transpiration, respiration, and other processes that result in the loss of ethylene gas, aromatic, and volatile organic compounds (Bovi *et al.*, 2018). One of the key metabolic processes that cause senescence and the eventual deterioration of fruits and vegetables is respiration (Adhikari & Aarati, 2021).

Fruits and vegetables are deprived of main nutrients and water when detached from their parent plant (Pedreschi & Lurie 2015), and continue to lose water through the mechanism of transpiration and respiration. For producers, processors, and distributors, these mechanism turns shelf-life into a race against the clock to maintain quality and reduce food loss (Mahajan *et al.*, 2014). This water

loss is generally related to economic loss as it induces a decrease in the saleable mass due to the product's shrivelling (Caleb *et al.*, 2013, Veraverbeke *et al.*, 2003).

Ethylene is widely known for its role in controlling the ripening, senescence, and final storage life of a wide range of horticultural commodities (Abeles *et al.*, 2012; Saltveit, 1999; Tucker *et al.*, 2017). However, whether produced internally or applied externally, ethylene can have an impact on the quality of these crops (Brizzolara *et al.*, 2020).

### **2.5.0 Postharvest Management Practices that Reduces Losses**

Postharvest management practices begin at harvest (Shewfelt *et al.*, 2022). Some of the activities carried out during this period include harvesting, pre-cooling, cleaning, disinfecting, sorting and grading, packaging, transport, and storage (Arah *et al.*, 2016).

Fruits and vegetables undergo several desirable (development of sweetness, colour, and flavour) and undesirable (water loss, shrinkage, shrivelling, cell wall degradation, softening, physiological disorder, over-ripening, disease attack, rotting, etc.) changes after harvest. It is not possible to stop the undesirable changes, but they can be minimized if proper postharvest management measures are employed (Nayik *et al.*, 2015).

### **2.5.1 Harvesting**

After determining the optimum maturity level and quality of fruits and vegetables, harvesting should be carried out with extreme caution since maturity levels can influence storage life (Ahmad

& Siddiqui, 2015). Pickers should be extra careful when digging, cutting, picking, handling, or plucking the fruit or vegetable from the plant to minimize damage and waste (Elik *et al.*, 2019). Excessive field heat generation can be avoided by harvesting fresh produce at the coolest portion of the day, either early in the morning or late in the afternoon (Bachmann & Earles, 2000). To prevent bruising and puncturing of the fruits, the use of sharp-edged harvesting and collecting vessels should be discouraged (Arah *et al.*, 2016). Crops should not be heaped at the farm's collection centre because this will result in rapid spoilage, particularly fruits in the centre of the heap; they should not be left to the mercy of the sun; a clean, cold, or well-ventilated shed should be provided for the immediate transfer of produce after harvest (Atanda *et al.*, 2011).

Melons should be harvested at the matured stage. Matured melon fruits especially the cantaloupes group can be easily detached from the stem when they reach the full slip stage. To reduce susceptibility to mechanical injury and extend the shelf-life, it is best to harvest the melon fruits at a mature but less ripe stage of development. Half-slip and quarter-slip fruits do not easily detach from the stem. Harvesting should be carried out manually since mechanically it is difficult to distinguish the proper stage of melon maturity to allow multiple harvests (Yahia *et al.*, 2011).

### **2.5.2 Pre-cooling**

In hot climatic regions, pre-cooling is vital in removing field heat from fruits and vegetables; this heat must be removed to prevent fruits from succumbing to rapid deterioration as a result of water loss, respiration process and ethylene production. When leaves exhibit wilting in the market or even before reaching the market, the price and appeal of the produce to the buyer will decrease; pre-cooling is therefore required to solve this problem (Faqeerzada *et al.*, 2018).

Pre-cooling reduces the effect of microbial activity, metabolic activity, respiration rate, and ethylene production, it also reduces ripening rate, water loss, and decay, thereby preserving quality and thus extending the shelf-life of the harvested horticultural product (Ferreira *et al.*, 1994; Shahi *et al.*, 2012).

Room cooling, forced air cooling, hydro-cooling, top or liquid icing, and vacuum cooling are all examples of pre-cooling methods (Ilyas, 2010). Dipping harvested produce in cold water (hydrocooling) combined with disinfection such as sodium hypochlorite is a low-cost but efficient method of pre-cooling (Adhikari & Aarati, 2021).

### **2.5.3 Cleaning, Disinfecting and Trimming**

Apart from postharvest diseases, food-borne illnesses can be transmitted to consumers through food crops; as a result of this, proper hygienic practices should be employed by food handlers (Arah *et al.*, 2016). Fresh fruits and vegetables must therefore be cleaned to remove soil dust adhering debris, insects, and spray residues before they can be marketed. In most cases, chlorine in freshwater is used as a disinfectant to wash the produce (Prasad *et al.*, 2018). Besides cleanliness, water used for washing improves the appearance of fruits and vegetables and prevents their wilting. Rotten, diseased, insect-damaged and discolored leaves of vegetables such as cabbage, spinach, lettuce and several others are trimmed off before they are ready for the market. Leafy greens such as green onion, spinach and fenugreek are tied in bundles (Ramjan & Ansari, 2018).

### **2.5.4 Packaging**

Packing can take place immediately in the field or in specially built facilities known as packinghouses. Most packing activities include removing foreign objects, sorting to remove

inferior products, sorting into selected size categories, evaluating samples to confirm that the fruit or vegetable lot satisfies a specific quality standard, and packed into a shipping container (Shewfelt *et al.*, 2022).

To reduce post-harvest losses as well as extend the shelf-life of fresh fruits and vegetables packaging plays a vital role in:

1. protection against microbial contamination and deterioration
2. protection against bruising and physical injury
3. protection against moisture/weight loss
4. providing ventilation for respiration and exchange of gases
5. slowing down respiration rate, delay ripening and increasing storage life
6. Controlling ethylene concentrations in the package (Ahmad & Siddiqui, 2016; Ahvenainen, 2003; Ramaswamy, 2014).

The choice of packaging materials usually depends on the harvested produce. Wooden crates, cardboard boxes, woven palm baskets, plastic crates, nylon sacks, jute sacks, and polythene bags are some of the most popular packing materials used in most developing countries (Adhikari & Aarati, 2021).

Improper packaging and the use of inappropriate packaging material are some of the main reasons why fruits and vegetables are lost at post-harvest stages. In the packing of fresh food crops, nylon sacks and wooden baskets should be avoided. When nylons sacks are used aeration becomes poor,

resulting in the build-up of heat due to respiration; wooden baskets on the other hand have rough surfaces and edges that can cause mechanical injuries to the produce (Hurst *et al.*, 2010).

Choosing clean, smooth, well-ventilated and crop-appropriate containers helps in reducing crop losses during harvesting, transportation, marketing, and storage (Atanda *et al.*, 2011).

### **2.5.5 Storage**

To improve shelf-life, increase profit, avoid market glut and ensure a constant supply of horticultural produce throughout the year, storage as well a good storage practices are required to reduce and control transpiration, respiration and disease infection at the same time maintaining life processes at the required level. Some storage methods include refrigeration, controlled /modified atmosphere, hypobaric, and zero-energy cool chambers (Nath *et al.*, 2018).

Depending on the commodity and storage conditions, fruits and vegetables can be placed in storage for a period ranging from a few hours up to several months. During storage, the shelf- life of a fruit or vegetable depends on its initial quality, storage stability, environmental conditions and methods of handling (Shewfelt *et al.*, 2022). In storage, food items do not improve. The basic purpose of the storage is to slow down the aging process caused by respiration, moisture loss and deterioration by diseases. The storage of fruits and vegetables is essential for extending the period of food availability and avoiding the problem of malnutrition. The technique, however, is solely based on scientific principles. Therefore, for successful storage of fruits and vegetables, one should know the basic principles behind (Khan *et al.*, 2017).

According to Kiaya (2014), before any produce is put in storage, it must always be of high initial quality, and the storage method chosen must be capable of keeping them cool (refrigerated, or at

least ventilated and shaded). In developing countries lack of proper storage facilities is identified as the main cause of post-harvest losses (FAO, 2013).

### **2.5.6 Transportation**

Transportation is one of the key causes of fresh produce losses as a result of the absence of appropriate means of transport, poor roads and inefficient logistics management between the period of production and consumption (ömer, 2018). Generally, fruits and/or vegetables are loaded onto trucks in wooden stacks, or simply piled onto the trucks. During transportation mechanical damage (fatigue) occurs because of vibrations that occur while traveling long distances, usually over untarred roads (Kimaro & Msogya, 2012; Mashau *et al.*, 2012).

To reduce losses, a clean and well-ventilated vehicle with a top cover should be used, loading and unloading of cargo trucks should be done with care, produce should be transported during the cool part of the day by driving slowly over smooth roads to reduce crop damage (Kimaro & Msogya, 2012; Kereth *et al.*, 2013). Commodity compatibility within a load must be taken into account by not mixing ethylene-sensitive commodities such as lettuce and ethylene generators such as apples (Ashraf *et al.*, 2012).

### **2.5.7 Marketing**

Gilbert *et al.* (2017), reported that the extent of loss for perishable horticultural crops is greater during marketing due to price instability, seasonality and market saturation. Marketing of horticultural produce is more different and challenging than industrial products because of their perishability, seasonality and bulkiness (Veena *et al.*, 2011). Perishable food produced in the farmer's field reaches the end consumer through a chain of intermediaries. These intermediaries carry out various functions, such as transfer of ownership of commodities, its movement,

maintenance and preservation of quantity and quality, payment to the seller, and commodity delivery to the buyer (Pati & Halder, 2011). Wholesalers, retailers and other middlemen are the key players in the marketing chain, from producers to consumers (Veena *et al.*, 2011). After harvest, most fresh fruits and vegetables usually end up in the retail market, where the consumer is left to either accept or reject the individual item or package product. Of all the handling steps, retail distribution is the most visible and often the least controlled (Shewfelt *et al.*, 2020).

A cooperative structure, as well as strong collaboration with the Agricultural Marketing Board, National Horticulture Board, and State Departments of Agriculture and Horticulture, must be formed to eliminate losses, restrict intermediary activity, and streamline horticultural produce marketing (Nath *et al.*, 2018).

### **2.5.8 Processing and Value Addition**

After harvest, the preservation of fruits and vegetables is an ongoing problem because of their highly perishable nature. To preserve the natural quality of fruits and vegetables, prolong their shelf-lives, and meet the demands of consumers and off-season markets, researchers around the globe are working hard to develop innovative technologies to achieve these (Abdelfattah *et al.*, 2020).

Processing can provide an extra source of income for the grower while also assisting in price stabilization through economic returns. Processing of horticultural produce takes care of gluts and wastes. During the peak season, excess produce can be processed, preserved and marketed during the off-season which will thereby minimize the post-harvest losses. Different value-added products can be prepared from various vegetables such as ready to cook (RTC) vegetables, tomato soup, jam, candy, canned peas, tomato sauce and ketchup, puree and paste, a frozen and dehydrated

product of capsicum, cabbage, French bean; oil, oleoresin, powder, pickles etc. of ginger and turmeric (Nath *et al.*, 2016).

Fruits and vegetables can maintain their tissue cells in a living state without postharvest chilling injury, destruction of cell structures and can ensure food quality when stored within the nonfreezing range of sub-zero temperatures (i.e. between ice temperature and supercooling) (Fukuma *et al.*, 2012; Min *et al.*, 2001).

## **2.6.0 Influence of Local Edible Coating Materials on the Physico – Chemical and Organoleptic Properties of Melon Fruits**

### **2.6.1 Edible Coating**

Edible coating/waxing is a postharvest practice that involves the application of an edible substance to the surface of agricultural produce (fruits and vegetables) to extend shelf-life and reduce decay without compromising product quality (Mahajan *et al.*, 2018).

Horticultural products that have benefited greatly from edible coatings during storage include, cherries (Martínez-Romero *et al.*, 2006; Mahfoudhi & Hamdi, 2015; Dong & Wang, 2018), plums (Valero *et al.*, 2013; Vishwakarma *et al.*, 2017; Thakur *et al.*, 2018), peaches (Maftoonazad *et al.*, 2008; Guillén *et al.*, 2013), apricots (Ghasemnezhad *et al.*, 2010; Zhang *et al.*, 2018) and nectarines (Ishaq *et al.*, 2009).

A report by Dhall (2016) indicates that the different types of waxing materials used are of animal origin (Bee wax, Shellac wax, Chinese insect wax, Spermaceti wax), vegetable origin (Candelilla

wax, Carnauba wax, Sugarcane wax, Esparto wax, Japan wax, Palm wax, Oricury wax) and synthetic and mineral origin (Montan wax, Ozocerite, Synthetic wax).

To improve the functional properties of the coating, several minor ingredients such as emulsifiers, plasticizers, surface-active agents, antioxidants, and antimicrobial agents are usually added to each coating composition (Njombolwana *et al.*, 2013; du Plooy *et al.*, 2009; Guerreiro *et al.*, 2015; Valencia-chamorro *et al.*, 2015).

Liquid coatings are the most commonly used and they are applied to the produce by either dipping, brushing, dripping or spraying (Andrade *et al.*, 2013; Tavassoli-Kafrani *et al.*, 2016).

According to Panghal *et al.* (2018) the benefits of wax coating include:

1. Improving appearance -wax retains color by protecting the product from browning, creates more shine, brilliance, and fresh appearance
2. Longer post-harvest life- waxing modifies atmosphere in the product leading to a decrease in oxygen content and an increase in the carbon dioxide content. This results in the reduction of the product's respiration rate and an increase in shelf-life after harvesting. On average, the wax extends shelf- life by 50 %
3. Reduced postharvest decay-waxing creates a hydrophobic layer and is pathogen resistant. Specific antimicrobial compounds may be included in the wax to enhance pathogen resistance to avoid losses

4. Less moisture loss - the tightly adhered coatings of wax close the pores in the outer layer/cuticle and reduce the rate of water vapor transmission. Wax coating application can reduce weight loss of product by 30% to 40%
5. Better market value fresh products payment is done based on weight and wax will not allow water losses which otherwise will lead to a reduction in economic benefits

During postharvest storage, the use of various fruit coating materials in the citrus industry is a common practice. The materials can avoid fruit shrinkage and weight loss, accompanied by shine, appearance enhancement and eventual marketability of the fruit (Contreras-Oliva *et al.*, 2011; Shi *et al.*, 2005; Contreras-Oliva *et al.*, 2012).

In various horticultural crops, waxing has been used to reduce postharvest diseases and stress damage (Hu *et al.*, 2012; Petracek *et al.*, 1998). The use of postharvest treatment method or handling practices does not enhance the quality of any fruit but only maintain it (Arah *et al.*, 2015).

### **2.6.2 Edible Coating and its Influence on the Physico – Chemical Characteristics of Fruits**

The outermost surface of some fruits such as grape, blueberry and plum are normally found to be covered with visible white or blueish cuticular wax (Saftner *et al.*, 2008, Wisuthiphaet *et al.*, 2014). This cuticular wax functions as the first defensive shield against biotic and abiotic stresses; it plays a crucial role in reducing the loss of non-stomatal water and in preventing the spore germination of pathogenic microbes (Bernard & Joubès, 2013, Mwangi & Kariuki, 2015).

Fruits and vegetables are stripped of their natural waxy cuticle during postharvest handling practices; to replace the lost natural wax, waxing materials are applied to the produce to impart a more durable protective barrier on the epicarp (Ali *et al.*, 2010; Thakur *et al.*, 2018). These replacements have played a vital role in reducing postharvest losses (Swamy *et al.*, 2020).

Apart from external quality attributes such as appearance, colour, size, and absence of blemishes (Opara and Pathare, 2014); internal quality parameters related to soluble solids content (SSC), titratable acidity (TA), soluble solids content to titratable acidity acid (SSC/TA) ratio and texture (Chen and Opara, 2013a; Chen and Opara, 2013b; Magwaza and Opara, 2015) are also taken into account when purchasing fruits and vegetables.

According to Lara *et al.*, (2014); Martin & Rose, (2014), cuticular wax has an impact on the postharvest quality of fruits. A sharp rise in postharvest water loss has been observed in fruits, such as citrus and European plum after the removal of wax from their surface (Mukhtar *et al.*, 2014; Wang *et al.*, 2014). Cuticular wax in Asian pear fruit can inhibit spore germination and mycelial growth of *Alternaria alternata* (Yin *et al.*, 2011).

### **2.6.3 Influence of Edible Coating on Total Soluble Solids (°Brix).**

The total soluble solids content (TSS) is a vital parameter of fruits (Xu *et al.*, 2019). Sugar accounts for about 75–85 % of total soluble solids in fruits, with the rest made up of acids, fructans, proteins, dissolved vitamins, minerals, phenolic compounds, and pigments (Magwaza

& Opara, 2015). Fruit with a high concentration of these elements is said to be nutritionally rich (Ahmed *et al.*, 2020). The maturity index of fruits is normally determined by measuring the relationship between the soluble solids content and titratable acid (Kader, 1996; Wei *et al.*, 2018).

Studies done by Basu *et al.* (2011) on the physicochemical properties of mango fruits by the application of edible coating showed that due to polysaccharide depolymerization, total soluble content increases during storage. Similar work done on tomatoes showed that storage conditions have a direct relationship with TSS (Dong & Beckles, 2019). A study conducted by Ahmed *et al.* (2020) on extending the shelf-life of guava fruit using date pit oil-based edible wax coating revealed that treatment and storage had a significant ( $p \leq .05$ ) effect on the TSS. The studies show that there is a direct relationship between the percentage increase of TSS and time. Waxing was reported to decrease TSS accumulation during ripening and storage in lime (Abdallah & Abu-Goukh 2010), papaya (Abu-Goukh & Shattir, 2012), and guava (Mohamed-Nour & Abu-Goukh 2013).

Abu-Shama *et al.* (2020), studies the effect of edible coatings on fruit quality of Barhi date cultivar. The authors reported that as storage day progresses, all treatments showed an increase in TSS, but the highest increase rate was recorded for the control.

Ebrahimi & Rastegar (2020), evaluated the effects of guar gum (GG) edible coatings enriched with *Spirulina platensis* extract (SPE) and *Aloe vera* extract on the physicochemical qualities of mango fruits (*Mangifera indica* L.) stored at the ambient temperature ( $25 \pm 2$  °C) for three weeks. The authors reveal that the mean TSS content was increased gradually during storage. The control had the highest TSS of 11.10 % whereas the GG + SPE coated fruits had the lowest of TSS 10.33 %.

#### **2.6.4 Influence of Edible Coating on Vitamin C**

Vitamin C, also known as ascorbic acid is water-soluble and cannot be synthesized by human bodies (Chebrolu *et al.*, 2012; Valente *et al.*, 2014). In the human diet, the primary source of vitamins C is fresh fruits and vegetables (Fenech *et al.*, 2019). Fruits and vegetables contribute

about 90% of the vitamin C requirement depending on the region and the amounts of fruits and vegetables consumed (Yahia *et al.*, 2019). It is widely agreed that eating a diet rich in vitamin C has a range of health benefits (Wintergerst *et al.*, 2006; Reczek & Chandel, 2015; Carr & Maggini, 2017; Van Gorkom *et al.*, 2018).

Mandal *et al.* (2018) evaluated the effect of edible coating on shelf-life and quality of local mango cv. Rangkuai of Mizoram. According to the authors, during the storage period, ascorbic acid content of fruit gradually decreased because of oxidation. It was recorded that, at four days after storage, ascorbic acid levels 26.41 - 39.42 mg/100 g dropped to 11.62 - 19.92 mg/100 g at 12 days after storage. After 12 days of ambient storage, wax-coated fruits had the highest amount of ascorbic acid content (19.92 mg/100 g) compared to control (11.62 mg/100 g).

Nasirifar *et al.* (2018) investigated the effect of active lipid-based coating incorporated with nano clay and orange peel essential oil on physicochemical properties of *Citrus sinensis*. According to the author, time, coating, and their interaction had a significant effect on vitamin C levels, and both coated and uncoated fruits experienced a decrease in vitamin C levels during storage. Vitamin C content was initially 61.34 mg/100 g, but after 100 days of storage, it had fallen to 49.52 mg/100g.

### **2.6.5 Influence of Edible Coating on Total Titrable Acids**

Total titrable acids (TTA) refer to the measures of all the acids present in a given fruit. Several investigations have been conducted into the effects of waxing on TTA. Li *et al.* (2018) examined the effect of the wax application on the ripening and storage quality of pineapple fruit.

The authors discovered that TTA increased during storage for the control and that the 40 g L<sup>-1</sup> wax treatment followed the same patterns as the control. There was no significant difference between the 40 g L<sup>-1</sup> wax treatment and the control except on ninth day. However, wax treatments of 65 g L<sup>-1</sup> and 90 g L<sup>-1</sup> inhibited the increase in TA content, which decreased within the first eleven days but slightly increased later. The TTA content of 65 g L<sup>-1</sup> and 90 g L<sup>-1</sup> wax treated fruit was lower than that of control and 40 g L<sup>-1</sup> wax-treated fruit. As a result, 65 g L<sup>-1</sup> and 90 g L<sup>-1</sup> wax treatment had higher TSS/TTA ratios. Hu *et al.* (2012) discovered that wax treatment reduced titrable acids of pineapple kept under cold storage conditions by approximately 6% and 5% compared with the control at 14 days and 21 days of storage, respectively.

Maina *et al.* (2019), evaluated the effect of waxing options on shelf-life and postharvest quality of “ngowe” mango fruits under different storage conditions. According to the authors, a general decrease in TTA content was observed in all fruits as ripening progressed, but the rate was significantly (< 0.05%) lower in cold storage compared to ambient storage. A combination of waxing and cold storage further delayed TTA reduction compared to ambient storage conditions.

Under ambient storage conditions, untreated “ngowe” mango fruit lost 86.35% equivalent of citric acid by the seventh day compared to an average of 62.78% for the treated fruits that occurred by the tenth day. For the cold-stored “ngowe” mango, untreated fruits lost 1.45% more citric acid six days earlier than the treated. Eshetu *et al.* (2019) examined the effect of beeswax and chitosan treatments on the quality and shelf- life of selected mango (*Mangifera indica* L.) cultivars. The studies revealed that there was a significant difference ( $p < 0.001$ ) in fruit titratable acidity during storage due to the treatments. The maximum value of titratable acidity (0.11%) was recorded for mango fruits treated with 2% beeswax and 2% chitosan in both variety and the minimum value (0.02%) was recorded for the control treatment at the end of storage.

### 2.6.6 Influence of Edible Coating on Firmness

The increasing activity of cell wall hydrolysis enzymes during ripening alter fruit firmness, resulting in fruit softening. Fruit softening is induced by pectin degradation, which results in the disassembly of the cellulose and hemicellulose network and a decrease in fruit firmness (Razavi & Hajilou, 2016). Aji *et al.* (2017) attempted to improve the shelf- life and sensory quality of pummelos by fruit waxing and wrapping. According to the authors, fruit firmness declined during storage. In contrast to un-coated and unwrapped fruits, coated and wrapped fruits were able to retain their firmness at two, four, six and eight weeks after treatment. At eight weeks after treatment, there was a significant increase in softness in the un-coated fruits, and fruits coated with either beeswax or chitosan at 103.54%, 49.08%, and 81.96%, respectively. Meanwhile, unwrapped fruits softened increase by 91.49 % and wrapped fruits softened increase by 52.39 %. Shahid & Abbasi (2011b), reported similar findings, suggesting that beeswax coating on sweet oranges kept the fruit hard during storage. A study by Abdolahi *et al.*, (2010) and Eshghi *et al.* (2014), revealed that the application of coatings and essential oils alone or in combination can improve the firmness of the fruit. Rokaya *et al.* (2016) investigated the effects of postharvest treatments on the quality and shelf- life of mandarin (*Citrus reticulata Blanco*). The authors observed that, in all the treatments, the fruit firmness decreased as the storage time progressed. The decreasing trend began in the first week and continued until the end of storage in all the treatments. In the first week, fruits treated with 10% wax in combination with 0.1% bavistin had the highest intact rate (4.16 kg/cm<sup>2</sup>), while the control had the lowest (3.78 kg/cm<sup>2</sup>). At the end of storage, the fruits treated with 10% wax plus 0.1% bavistin had the highest firmness rate (3.08 kg/cm<sup>2</sup>), followed by 10% wax (3.03 kg/cm<sup>2</sup>), and then the control had the lowest firmness rate (2.09 kg/cm<sup>2</sup>).

### 2.6.7 Influence of Edible Coating on pH

In the preparation of beverages, the pH of fruit juice plays a vital role. During storage, the pH of the juice increased, which might be attributed to a decrease in acidity (Bhardwaj & Pandey, 2011). Eshetu *et al.* (2019) examined the effect of beeswax and chitosan treatments on the quality and shelf- life of selected mango (*Mangifera indica L.*) cultivars. The studies revealed that there was a significant difference ( $p < 0.001$ ) in fruit pH during storage due to the treatments. At the end of storage, 'Apple' mango coated with 0.5% chitosan had maximum increase (5.15) in pH, while those coated with 2% of beeswax had the minimum pH of 4.00. The minimum and maximum pH of 'Tommy Atkins' was 4.25 and 5.00 in the fruit treated with 0.5% and 1.5% chitosan, respectively while pH of 6.20 was recorded for control treatment at the end of storage time. The minimum and maximum pH 4.51 and 4.82% was recorded between 'Tommy Atkins' and 'Apple' fruits, respectively and there were significant differences between varieties.

Ahmed *et al.* (2020) formulated date pit oil-based edible wax coating for extending the storage stability of guava fruit. They demonstrated that the pH had increased slightly. Controlled samples had a higher pH change than coated samples. The result depicted that T<sub>4</sub> (2% wax) had a minimum increase in the pH followed by T<sub>3</sub> (1.5% wax), T<sub>2</sub> (1%), and T<sub>1</sub> (0.5%). On the final day of the trial, it was found that T<sub>0</sub> (0% wax) had a maximum increase (4.57%) in pH, followed by T<sub>1</sub> (3.42%), T<sub>2</sub> (2.38%), T<sub>3</sub> (2.34%), and T<sub>4</sub> (1.30%). Al-Harrasi *et al.*, (2014) study on the edible coating of guava fruits appears to be quite close to the current findings. The change in pH may be attributed to a decrease in the amount of maleic acid, as a result of rise in respiration during storage.

Kumar *et al.* (2020) investigated the effect of chitosan: pullulan (50:50) blend edible coating enriched with pomegranate peel extract on the quality, sensory attributes, and shelf- life of litchi fruit cv. Deshi stored for 18 days at room temperature ( $23 \pm 3^{\circ}\text{C}$ , RH- 40-45%) and cold

temperature ( $4 \pm 3^{\circ}\text{C}$ , RH- 90-95%). They observed that the application of chitosan and pullulan (50:50) blend edible coating were highly effective to control the reduction of pH of litchi at both storage conditions (room and  $4^{\circ}\text{C}$ ) compared to controls.

Ali *et al.* (2016), investigated the shelf life of grapes with aloe vera coatings suspended in water at concentrations of 0%, 10%, 20%, and 30% aloe vera. These were stored in poly packaging and open plates at temperatures ranging from 0 to 300 degrees celsius in a refrigerator and incubator. The author's reported that, during storage, the pH of the grape juice was found to be steadily increasing. From the 14th to the 21st day, grape juice stored at  $30^{\circ}\text{C}$  in an incubator showed acidic behavior. This was due to the browning, decaying, and microbial attack on the grapes due to packaging and high temperature effect. At  $30^{\circ}\text{C}$  and unpackaged conditions, the pH of uncoated grapes reached 6.96. This was because they had completely lost all of their moisture during the storage period. The pH of packaged grapes stored at  $40^{\circ}\text{C}$  was the lowest. Except for the 20% coating, the pH of all the coating concentrations did not vary significantly. Between the two treatments, there was no significant difference (10.0% and 30.0%).

It was found that coated grapes had a higher value at the end of the storage period; this was attributed to the semi-permeability created by aloe vera coatings on the fruit's surface, which might have altered the internal environment, i.e. endogenous  $\text{O}_2$  and  $\text{CO}_2$  concentrations in the fruit, thus delaying ripening.

Oyeleke & Odedeji (2011), also discovered that pawpaw fruits treated with palm kernel oil retained a higher pH than bee waxing treatment and chemical waxing treatment.

### 2.6.8 Influence of Edible Coating on Weight Loss

Weight loss is used as a quality indicator for fruits after harvest. Fruit shriveling and decay are caused by the natural metabolic mechanism of moisture evaporation through the fruit surface (Khaliq *et al.*, 2015).

Beeswax in coating acts as a hydrophobic agent, preventing water vapour from passing through the coating and therefore minimizing mass loss (Oliveira *et al.*, 2018). The effects of locally produced waxing materials on the shelf life and fruit quality of two tomato varieties (*Solanum lycopersicum*) was assessed by Osae (2017), the studies revealed that beeswax treatment showed the minimum weight loss (26.5%) and also Beeswax treatment and its combinations was able to reduce weight loss than the other treatments.

Studies by Orishagbemi *et al.*, (2015) on the effect of coating/waxing preservation on the biochemical properties and nutrient composition of some indigenous tropical fruits revealed that Shea butter exhibited the strongest tendency to prevent moisture loss, resulting in a weight loss of no more than 5%, allowing avocado to keep its freshness during storage.

Anjum *et al.*, (2020), evaluated the effect of gum arabic and Aloe vera gel-based edible coatings in combination with plant extracts on postharvest quality and storability of 'Gola' guava fruits. The studies revealed that physiological weight loss of guava fruits increased as the storage period progressed. Higher weight loss was recorded in control (28%), while ginger extract + gum arabic coated guava fruits recorded (22.36%), garlic extract + gum arabic had (20.65%) and gum arabic + aloe vera coating (21.76%).

Al Fadil *et al.* (2015) evaluated the effect of potassium permanganate (KMnO<sub>4</sub>) and waxing on the quality and shelf-life of the three 'Galia' cultivars at 18 ± 1 ° C and 85%-90% relative humidity.

The authors reported that weight loss increased gradually during the storage of

'Galia' fruits. In the three 'Galia' cultivars, waxed and/or potassium permanganate-treated fruits lost slightly lower weight than the control fruits. After six days in storage, weight loss in the untreated fruits was 22 % in the three cultivars. At the same time when compared to the control, weight loss in the KMnO<sub>4</sub> treated, waxed, and waxed and KMnO<sub>4</sub> treated fruits was reduced by an average of 6.5 %, 16.2 %, and 27.6 %, respectively.

Khaliq *et al.* (2015), examined the effect of gum arabic (GA) 10% and calcium chloride (CA) 3% on the physiological and biochemical properties of mango (*Mangifera indica* L. CV. Choke Anan) fruits stored at low temperature. The authors found out that, all samples showed a gradual loss of weight during storage. Weight loss of untreated mango fruits was significantly ( $P \leq 0.05$ ) higher than treated fruit after 14 days up to the end of the storage period.

Chen *et al.* (2019) investigated the effects of carnauba wax (CW) and CW containing glycerol monolaurate (CW-GML) coating on physico-chemical and qualitative attributes of jujube fruit stored at 20 °C for 12 days. The authors reported that weight loss increased continuously in all treatments during storage, but CW or CW-GML coating was able to limit weight loss as compared to the control treatment. The weight loss of CW-coated jujube was 4.43 % and CW-

GML-coated jujube was 4.29 % on the eighth day of storage, which was less than the commercial weight-loss limit of 4–6% for fresh fruits. The weight loss of the control fruit was 19.5 % after 12

days of storage, but only 8.2 % and 7.5 % for the CW-coated and CW-GML coated fruits, respectively.

The single or combined CW coating has been used to effectively conserve water content in a variety of fruits, including eggplant with 15.8% water loss for 12 days of storage at 20 °C (Singh *et al.*, 2016), pomegranate with 10% water loss at the 60th day of cold storage (Barman *et al.*, 2011), and apple fruit with 4–5% water loss for 180 days at 1 °C (Jo *et al.*, 2014).

According to Ganiari *et al.* (2017), tomatoes treated with edible covering and antioxidant extract (CE) lost substantially less weight than tomatoes treated with cover without extract and control.

### **2.6.9 Influence of Edible Coating Pathogens**

Duan *et al.* (2018) investigated the effectiveness of wax (W) with Cinnamaldehyde (WCA) in controlling green mold decay in citrus fruits. The studies discovered that, before five days of storage, a WCA treatment effectively decreased fungal growth in citrus fruits inoculated with *P. digitatum*. After three days of incubation, the incidence rate in wax-treated fruits was 23%. However, this percentage was reduced to 10% in citrus fruits coated with WCA (1x MFC), whereas fruits treated with WCA (10 x MFC) were not infected. Green mold decay grew increasingly as storage time increased. After five days of storage, green mold incidence rates in wax-treated and WCA (1 x MFC)-treated fruits were up to 100% and 93 %, respectively while it was just 33% in WCA (10 x MFC)-treated fruits. A similar work by Sripong *et al.* (2020) to assess the impact of paraffin wax and propolis on controlling crown rot disease of banana revealed that the incidence and severity of crown rot disease were significantly reduced by a combination of paraffin wax and propolis treatment, which was equivalent to using 250 ppm prochloraz. Un-coated (control 1), propolis and paraffin wax alone established disease incidence faster than the combined treatment

and prochloraz (control 2). The un-coated and individual propolis and paraffin wax treatments had 50% disease incidence at day 14 of storage, while the sample treated with the combined treatment and prochloraz did not show any visible decay until day 21. However, when the samples were kept at 25°C, all treatments showed a 100% disease rate. Furthermore, when paraffin wax and propolis were used together, the incidence of crown rot disease was decreased in a similar way to when prochloraz was used. At the end of storage, the combination and prochloraz treatments had a severity score of 2.25 and 2.00, respectively, while the single paraffin wax and propolis treatment had a severity score of 3.25 and 3.50, with no significant differences as compared to the control (3.50 score). The effect of the combined treatment on disease reduction could be due to coating the cut surface of the banana crown with paraffin wax, which can serve as a shield against pathogenic infection, as well as a coating material containing propolis, which is a powerful antimicrobial agent (Pobiega *et al.*, 2019).

## **2.7 Organisms Associated with Postharvest Rot of Melon Fruits**

Horticulture produce are typically eaten raw and are increasingly being recognized as effective vehicles for the transmission of human pathogens (Ramees *et al.*, 2017). They can be a source of food-borne infections and disease outbreaks because they are consumed raw or slightly cooked to maintain their flavor and nutrient content (Mir *et al.*, 2018). Faeces, harvesting equipment, human handling, insects, wild and domestic animals, methods of transportation, processing equipment, dust, and rinse water are among the sources of postharvest contamination (Gil *et al.*, 2015).

Melon farmers in Brazil have estimated that about 15% of exported melon has been lost due to postharvest diseases, resulting in an average loss of \$22 million per season (Oster *et al.*, 2018). Infections caused by pathogens are the most common cause of melon fruit losses during

postharvest handling; through physical and physiological injury, they can gain entry and infect the fruit (Lima *et al.*, 2021).

*Fusarium semitectum* was identified as the pathogen responsible for melon fruit rot based on morphological markers (De Oliveira *et al.*, 2014). *Fusarium* species have been recorded in various production areas worldwide to cause postharvest rot, and are considered one of the most important diseases limiting melon commercialization (Mahdikhani & Davoodi, 2016).

*Fusarium incarnatumequiseti* species complex (FIESC) species have recently been identified as the cause of postharvest rot in melon in Thailand (Nuangmek *et al.*, 2017; Wonglom & Sunpapao, 2020) and China (Wonglom & Sunpapao, 2020).

Abdullah *et al.* (2016), isolated and identified pathogens associated with postharvest rot of some fruits in Yemen. The results of the study revealed that *Aspergillus* was the genus most frequently isolated from different types of mouldy fruits, with rates ranging from 0% to 93.3% of samples recovered, with the highest incidence observed on apple and grape and a low incidence on the banana. On orange and mango fruits, *Aspergillus* was recovered in 86.7% and 80% of the samples. *A. niger* and *A. flavus* were the most common species among the nine species of *Aspergillus*. They were respectively recovered from 20% to 60% and 13.3% to 60.0% of the different mouldy fruits samples. The isolation of these pathogens was verified in India by Fatima *et al.* (2012), who discovered that the long time it takes to transport fruits throughout the world, combined with rising humidity, favors the production of *Aspergillus* rot of fruits.

Similar work by Mailafia *et al.*, (2017) in Abuja, Nigeria revealed that pineapple, watermelon, grapes, pawpaw, and tomatoes had the highest prevalence of *Aspergillus niger*, with a frequency

of 38%. *Fusarium avenaceum* was next, with a 31.1 % level of occurrence in fruits like pineapple, watermelon, bananas, pawpaw, and tomatoes while *Penicillium digitatum* and *Rhizopus stolonifer* had the least frequency of 4% each in tomato, orange and tomato, respectively. Yeast (*Saccharomyces species*) (10%), *Fusarium solani* (8%), and *Aspergillus flavus* (5%) were the other fungal species identified. *A. niger* had the highest prevalence rate, with 70% of isolates recovered from orange, followed by *F. avenaceum*, with 65% of isolates recovered from pawpaw. Other fungal organisms including yeast (*Saccharomyces species*), *P. digitatum*, and *R. stolonifer* were isolated with varying degrees of prevalence (40 %, 20%, and 5%,) from watermelon, tomato, and orange, respectively.

### **2.8 Pathogenicity of Yellow Melon Fruit Rot**

Pathogenicity is the ability of an organism to cause disease to its host. During postharvest handling, horticultural produce can be easily infected with pathogens if not handled properly. A pathogenicity test can be performed by infecting a healthy fruit with the disease sample and after a few days, the infected fruit is observed for signs of disease symptoms.

Zhang *et al.* (2019) carried out studies to identify the fungal pathogen species that cause postharvest peach diseases and the potential and mechanisms of using the *Bacillus subtilis* JK-14 to control the diseases. The authors discovered that the difference in disease incidences of infection caused by the six fungal isolates on the mature fruits was highly significant between intact and wounded fruits. The non-inoculated control fruits, thus the intact and wounded did not develop decay symptoms, whereas all the wounded fruits developed rot and decay, regardless of the isolates used. After inoculating the isolates of *A. tenuis*, *B. cinerea*, and *R. nigricans* onto the wounded fruits, the disease incidence recorded was 100%. The highest disease incidence was also observed

after inoculating with the isolates of *A. tenuis* and *B. cinerea* on the intact fruits, and the disease incidences were 100% and 92.33%, respectively.

Li *et al.* (2017), isolated and identified pathogenic fungi causing postharvest fruit rot of kiwifruit (*Actinidia chinensis*) in China, the authors reported that from the third day after inoculation, the infected flesh below the skin of the fruit showed disorganized soft decay in the wounds of all the 76 strains. In contrast, all non- inoculated controls and unwounded fruit remained undecayed except *B. dothidea* strains, indicating that all pathogens were able to infect kiwifruit through wounds on the skin but only *B. dothidea* strains were able to infect fruit with unwounded peel.



## CHAPTER THREE

### 3.0 MATERIALS AND METHODS

#### 3.1 Introduction

The study was conducted in two phases. The first phase focused on the postharvest handling practices survey, while the second phase was on laboratory investigation.

#### 3.2 Study Area

Phase one was conducted at Afiencya in the Ningo- Prampram District of the Greater Accra, where data on postharvest handling practices along the yellow melon value chain was collected. Phase two was conducted at the University of Ghana's Postharvest and Pathology Laboratories, as well as the Biochemistry Laboratory, where data on physicochemical, pathological, organoleptic, and shelf-life were collected.

#### 3.3.0 Assessing the Postharvest Management Practices along the Yellow Melon Value Chain

##### 3.3.1 Sampling Size and Method

Six farmers and six traders were involved in the pre-testing of the questionnaires. This was done to ascertain the appropriateness of the questions in obtaining the needed data for the study. The internal consistency of reliability of the individual questions were confirmed using Cronbach's Alpha coefficient test (Gall *et al.*, 1996). Fifty producers and dealers (transporters, wholesalers, and retailers) each were interviewed for the study. Purposive sampling was used to select the producers and dealers while respondents for each group were randomly selected to avoid bias. The final structured questionnaires (consisting of both close-ended and open-ended questions) as well

as field observation, were used to collect data. Field observations were recorded in the form of pictures. Information on demographic characteristics, management practices (harvesting, packaging, storage, and transportation), perception of farmers and dealers on the waxing of yellow melon fruits after harvest, knowledge about postharvest losses, and causes of these losses were collected.

### **3.4.0 Laboratory Assessment of Changes in Quality Yellow Melon fruits treated with different waxing materials**

#### **3.4.1 Source of Samples and Waxing Materials Used**

Yellow melon (*Cucumis melo*) samples were sourced from local farmers in Afienya and transported to the laboratory at the Department of Crop Science at the University of Ghana for analysis. Shea butter was sourced from Tungteiya Shea Butter Association-Tamale, Beeswax from Alpha Honey - Accra, and Neem oil from Agrimat - Accra.

#### **3.4.2 Sample Preparation, Wax Application and Storage**

To maintain the uniformity of the experimental materials, only uniform fruits (in terms of overall appearance, variety, size, shape, and stage of maturity), free from pest and disease, injuries, bruises and blemishes were selected. The fruits were washed in chlorinated water to remove dirt and then wiped with a clean disposable tissue towel. Apart from the control, the remaining fruits were treated with different waxing materials after the cleaning process.

Seven waxing treatments (Shea Butter, Neem Oil, Bee Wax, Shea Butter + Bee Wax, Shea Butter + Neem Oil, Neem Oil + Bee Wax, Shea Butter + Bee Wax + Neem) were used for coating the yellow melon fruits.

### **3.4.3 Shea Butter Wax**

Shea butter was placed into a clean aluminum pan and heated over an electric cooker. The butter was allowed to completely melt and one hundred millilitres measured. The melted butter was then allowed to cool before it was applied to the surface of the fruit by dipping. The melted butter was re-heated and cooled anytime it solidified and there was the need to use again as a treatment. It was ensured that the shea butter was applied uniformly to the entire surface of the fruits.

### **3.4.4 Neem Oil Wax**

One hundred millilitres of the neem oil was measured using a volumetric flask and poured into a clean bowl. To coat the surface of the melon fruits, the fruits were dipped into the neem oil making sure that the entire surface of the fruits is uniformly treated with the neem oil.

### **3.4.5 Beeswax**

Beeswax was placed into a clean aluminum pan and heated over an electric cooker. The solution was stirred continuously until it melted and one hundred millilitres measured. The melted wax was then allowed to cool before it was applied to the surface of the fruit by dipping. The wax was re-heated anytime it solidified and cooled for reuse. The beeswax was uniformly applied to the entire surface of the fruits.

### **3.4.6 Shea Butter + Beeswax**

A mixture of shea butter and beeswax was obtained by measuring 100ml each of the melted shea butter and the beeswax. The mixture was then allowed to cool a little before it was applied to the entire surface of the fruits by dipping. The shea butter and beeswax mixture was reheated anytime it solidified and cooled a little before application of treatment.

### **3.4.7 Shea Butter + Neem Oil Wax**

One hundred millilitres of melted Shea butter was measured and added to fifty milliliters of neem oil. The mixture was stirred thoroughly to form a uniform mixture and then allowed to cool a little before it was applied uniformly to the fruits by dipping the surface of the fruit. The shea butter and the neem oil mixture was re-heated anytime it solidified and cooled a little before application of treatment.

### **3.4.8 Neem Oil + Beeswax**

One hundred millilitres of melted beeswax was measured and added to fifty milliliters of neem oil. The mixture was stirred thoroughly to form a uniform mixture. The uniform mixture was then allowed to cool a little before it was applied uniformly to the fruit by dipping. The neem oil and beeswax mixture was re-heated anytime it solidified and cooled before using.

### **3.4.9 Shea Butter + Beeswax + Neem oil**

One hundred millilitres each of melted shea butter and the beeswax were measured and added to fifty milliliters of neem oil. The three were mixed thoroughly to form a uniform mixture. The mixture was then allowed to cool a little before it was applied to the fruit by dipping. The shea butter, beeswax and the neem oil mixture was re-heated anytime it solidified and cooled before using.

All of the coated fruits were allowed to air dry after the wax application. The fruits were packed according to the experimental layout, labelled and stored at room temperature in the laboratory.

### 3.4.10 Description of Experimental Treatments

Eight (8) treatments were laid out in Completely Randomized Design (CRD) with three replications of 18 fruits per treatment. A total of 432 fruits were used. The treatments were as follows:

No.	Treatments	Ratio (ml)
T1	Control (No Wax)	-
T2	Shea Butter	-
T3	Neem Oil	-
T4	Bee Wax	-
T5	Shea Butter + Bee Wax	1:1
T6	Shea Butter + Neem Oil	1: 0.5
T7	Neem Oil + Bee Wax	0.5:1
T8	Shea Butter + Bee Wax + Neem Oil	1:1:0.5

Preliminary research led to the selection of the above ratios. Several concentrations were tried, and it was discovered that raising or decreasing the ratio had no effect, necessitating the need to choose these ratios.

### 3.5.0 Data Collection

Data on randomly selected fruits in each treatment per replication was recorded at 0, 3, 6, 9, 12, 15 and 18 days of storage. The quality indices measured included weight loss, firmness, pH, total soluble solids (TSS), titratable acids (TA), vitamin C. and shelf-life. In addition to the quality indices, sensory evaluation, isolation and identification of pathogens associated with yellow melon fruit rot, and pathogenicity studies were carried out.

### 3.5.1 Percentage Weight Loss (% WL) Determination

For the determination of weight loss during storage, 4 yellow melon fruits out of the 18 fruits from each treatment were marked at the start of the experiment and kept separate for periodic weighing using an electronic weighing scale (Park *et al.*, 1994).

The weight of each marked melon fruit from each treatment was derived as a result of the difference between the initial weight (W1) of the fruit (marked) at day 0 and the new weight of the same fruit (W2) for the subsequent days. Three different readings were taken with their simple averages computed. The 'TARE' button of the weighing scale was used to reset the scale to zero after every weight was taken to acquire accurately the final weight of the melon. The scale was wiped clean after every use.

The percentage weight loss (%) was computed using the equation:

$$\text{Total weight loss (TWL) \%} = \frac{W1 - W2}{W1} \times 100$$

TWL% = Percentage total weight loss over a period

W1 = Initial weight of fruit (Day 0)

W2 = Final weight of fruit (Days at 0, 3, 6, 9, 12, 15 and 18)

### 3.5.2 Fruit Firmness (FF) Determination

The firmness of the yellow melon fruits was obtained using the TR Turoni hand-held penetrometer with a 5 mm probe ([Abbott, 1999](#)). Three yellow melon fruits were randomly selected from each treatment and their firmness was determined. The tip of the penetrometer was pushed against the surface of the fruit till it fully penetrated the skin. The maximum force required to puncture the equator region of fruit was recorded. Three different readings were taken from the equator region of each fruit and the average computed. Firmness was expressed in Newton (N). The tip of the penetrometer was rinsed with distilled water and wiped clean after every use.

After fruit firmness has been measured with the hand penetrometer, the same fruits were used to determine the pH, TSS and TTA.

### 3.5.3 Total Soluble Solids Determination (TSS)

An Atago pal digital hand-held pocket hand refractometer was used to determine the TSS levels (Cheour et al., 1991).

A drop of distilled water was placed on the prism and zeroed. After zeroing, the water was wiped off with a disposal tissue. The fruits were sliced and the juices squeezed unto the prism of the refractometer. The refractive index was then read and an average of three readings was recorded. The process of zeroing was repeated preceding each sample readings.

### 3.5.4 Titratable Acidity Determination (TTA)

The TTA was determined by titration. Ten grams of the melon fruit was grounded in a mortar and 45 ml of distilled water added to the grounded fruit to form a homogenized solution.

The solution was filtered through a muslin cloth. Ten milliliters of the dilute solution was

transferred into a 125mls conical flask, then mixed with three drops of phenolphthalein indicator (colorless in acid medium) for titration against 0.1M NaOH with constant shaking, till the mixture showed the appearance of pink color. The titre values were recorded and the percentage citric acid was calculated using the method described by Mitcham *et al.*, (1996).

$$\% \text{ Acidity} = \frac{\text{Mls NaOH} \times \text{Normality (NaOH)} \times 0.064^*}{\text{Volume of Sample (ml)}} \times 100$$

Volume of Sample (ml)

Where 0.064\* = acid milliequivalent factor.

### 3.5.5 pH Value Determination

An electronic pH meter was used to determine the acidity of the fruits according to Association of Official Analytic Chemist (AOAC) method (1990).

A melon fruit to be analyzed was cut and the juice squeezed out into a beaker. The glass electrode of the pH meter was inserted into the beaker containing the melon juice and the reading was taken. The glass electrode was washed with distilled water after each reading. The pH meter was calibrated with buffer solutions.

### 3.5.6 Dye standardization

Fifteen milliliters of 2,6-dichlorophenol indophenols solution was added to a 5ml saturated solution of potassium iodide in the presence of 10ml 1N HCL and allowed to stand for 2 minutes. It was titrated with 0.01N freshly prepared sodium thiosulphate using starch as an indicator till there was no colour change.

The dye equivalent was calculated as follow:

$$1\text{ml dye} = 1/1000 \times \text{ml Na}_2\text{S}_2\text{O}_3 \times \text{normality of Na}_2\text{S}_2\text{O}_3 \times 88 \times 1000/\text{ml dye.}$$

### 3.5.7 Vitamin C Determination

Vitamin C (ascorbic acid) was determined by the titrimetric method according to (AOAC, 1996; AOAC 967.21). Twenty grams of fruit was blended and the volume was made up to 100 ml with 0.4% oxalic acid in a volumetric flask and filtered. Five millilitres of filtrate and 15ml 0.4% oxalic acid was pipetted into a conical flask and titrated with the standard redox dye (2, 6 – dichlorophenol indophenols) in the burette until the solution turned pink and remained at this colour for 10 seconds. This meant that all the ascorbic acid in the solution was used up and therefore, there was no electron available to reduce the 2, 6 – dichlorophenol indophenols. The titration reading was calculated by the following formula;

$$\text{Ascorbic acid (mg/100g)} = \text{Titre} \times \text{Dye equivalent} \times \text{dilution factor.}$$

### 3.5.8 Shelf-Life Determination (SL)

The fruits were stored at room temperature until they began to rot. The shelf-life was recorded as the number of days it took for decay to appear on the fruit.

A Thermo Pro indoor humidity and temperature monitor (Model No.: TP -50) was used to measure the temperature and relative humidity of the storage area during the storage period.

### **3.6 Sensory Evaluation of yellow melon fruits**

A semistructured questionnaire was used to collect data on consumer acceptability of yellow melon fruits treated with different waxing materials. Blindly Coded samples were served to each of the 10 untrained panellists selected from the College of Basic and Applied Sciences in the University of Ghana to score samples for attractiveness, glossiness, flavour, skin/rind colour, pulp colour, mouthfeel, texture, taste and overall acceptability. A five-point Hedonic scale as described by Sugri *et al.* (2010) was used.

### **3.7.0 Isolation and Identification of Pathogen Associated with Yellow Melon (*Cucumis melo*) Rot.**

#### **3.7.1 Preparation of Potato Dextrose Agar (P.D.A)**

The medium used for the isolation of fungal microorganisms was Potato Dextrose Agar (PDA). Potato Dextrose Agar (P.D.A) was prepared by mixing 7g of P.D.A in 200 ml distilled water in a 250 ml conical flask. Having shaken the content to ensure a uniform dissolution, the flask was plugged with cotton wool and later covered with aluminium foil. The conical flask with its content was then autoclaved at 1.05 kg/cm square pressure at 121 °C for 15 minutes, after which it was cooled in a water bath. The content of the conical flask was later poured into Petri dishes that were sterilized using a hot air sterilizer at 175 °C for about 2 hours in a laminar flow set. The laminar flow was sterilized with infiltration of air and the table of the laminar flow was sterilized with 70% alcohol before the isolation was carried out.

#### **3.7.2 Isolation of Pathogens**

Isolation of fungi was done using the classical phytopathological method. Yellow melon fruits showing symptoms of rot were used for the isolation of microorganisms. About 8-10 mm of the fruit was cut from points showing visible signs of spoilage to the healthy portions using a

sterilized blade. The cut portion was firstly immersed in distilled water to wash off dirt then into 1% sodium hypochlorite for about 20-30 seconds to sterilize them. The sterilized portions were then picked out of the 1% sodium hypochlorite solution using sterilized forceps and then placed on clean disposable tissue to drain excess moisture. The cut portion was later plated on the P.D.A at a rate of three cuts per plate and labelled according to the treatment and the date of plating. The plates were then covered and placed in plain polyethylene bags and incubated at room temperature and observations made for microbial growth.

After 5–7 days of growth, subculturing was done to obtain pure cultures of the isolates. To subculture the organism isolates, a wire loop was flame sterilized and used to scoop out a little quantity of each pathogen and inoculated in another Petri dish containing solidified PDA. The loop was used to streak the inoculums on the PDA and left to grow. The plates were sealed with PVC tapes to avoid contamination. Plates were incubated for 5–7 days at room temperature.

### **3.7.3 Identification of Pathogens**

Identification was done macroscopically and microscopically. For macroscopic identification, colony characteristics such as appearance, change in medium colour and growth rate were observed on the Petri plates. For microscopic identification, a thin smear of organism isolates from 5–7 day old cultures were inoculated aseptically on a clean glass slide using a sterile inoculating loop. Slides of the isolates were later observed under a compound microscope. The isolated organisms were identified using Agrios (1988) and (Barnett & Hunter (1972) approach. and with the help of the technicians at the pathology laboratory. Techno spark 5 digital camera was used to take micrographs of the pathogens through the lens of the compound microscope.

### **3.8 Pathogenicity of yellow Melon Rot**

Healthy yellow melon fruits were washed with distilled water and thereafter sterilized in one percent sodium hypochloride solution for 30 seconds. Mycelia discs of organism isolates from five-day-old cultures were used to inoculate the yellow melon fruits. The cylindrical plugs (5 mm) were used to plug holes created in the yellow melon fruits by a cork borer. The discs of the yellow melon fruits in the cork borer were replaced and sealed with sterile PDA.

On the appearance of symptoms, the tissues at the margin of the healthy and diseased parts were excised, sterilized and placed on PDA and incubated at room temperature for 5–7 days. At the end of this period, morphological characteristics and growth patterns observed in each case were compared with the ones of the original isolates. Two yellow melon fruits were used for each organism isolate, replicated three times and arranged in a Complete Randomized Design (CRD).

Controls were yellow melon fruits inoculated with sterile PDA only. After 5–6 days of postinoculation, the hand feel and visual examination of the exterior and interior of the fruits were used to ascertain the symptoms of fruit rots.

### **3.9 Data Analysis**

The data collected on the laboratory experiments and sensory evaluation were subjected to analysis of variance (ANOVA) using Genstat 12<sup>th</sup> Edition and the means were separated using least significant difference (LSD) at 5%. Data that needed to be transformed before analysis was transformed using square root transformation. The data collected on consumer acceptability and assessment of postharvest management practices with the questionnaire were analyzed using SPSS Version 26. Identified pathogens responsible for rot and pathogenicity of the yellow melon were also described using recommended books.

## CHAPTER FOUR

### 4.0 RESULTS

#### 4.1.1 Gender of Respondents

Majority of the farmers interviewed were males representing 96% while 4% were females. For the traders, 94% were females and the males constituted 6% (Figure 4.1).

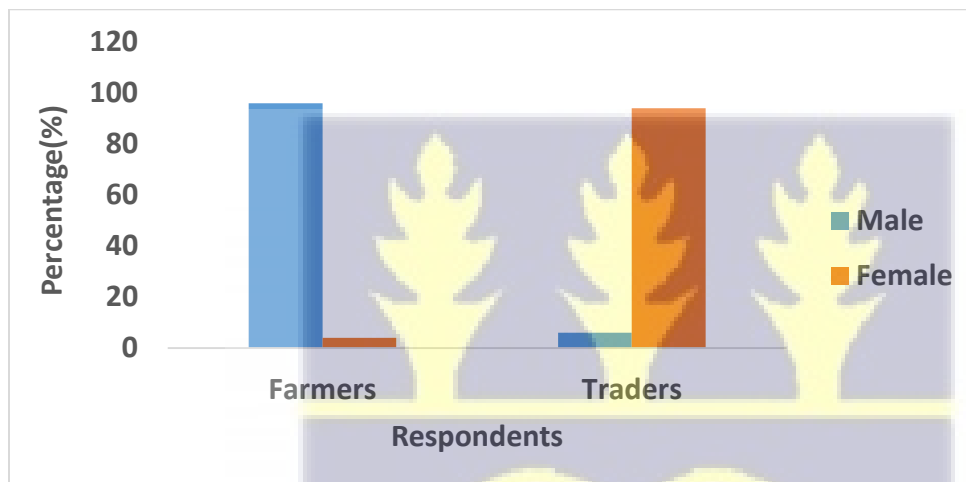


Figure 4.1 Gender of respondents

#### 4.1.2 Educational Level of Respondents

The educational level of respondents showed that 32% of the farmers and 20% of the traders had no formal education. The percentage of farmers and traders who had primary education were 20% and 10%, respectively. For JSS/JHS graduates, farmers were 22% while traders were 36%. Only 2% farmers and 6% of traders had tertiary education (Figure 4.2).

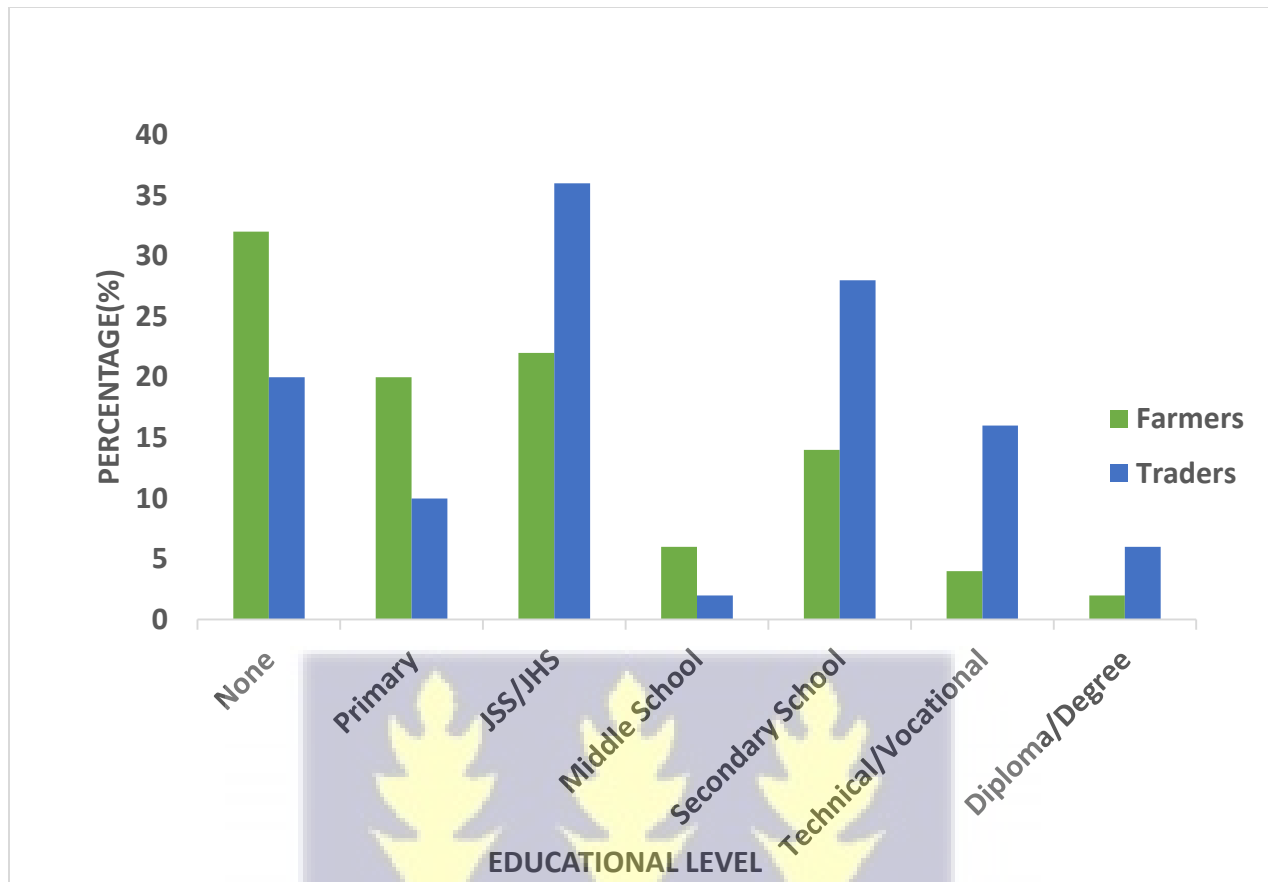


Figure 4.2 Educational level of respondents

#### 4.2.0 Post-Harvest Handling Practices along the Yellow Melon Value Chain in Afienea

It was observed that the value chain of yellow melon fruits starts from pre-harvest to harvest then postharvest stage. Activities carried out at the various stages influenced the final quality of the fruits.

Field preparation, planting, watering, weeds, insect pests and diseases control were among the pre-harvest activities the farmers employed on their farms. Most of the farmers used their own saved-seeds and cultivated the crop more than twice a year because of the irrigation facility on site.

The study revealed that before harvest, farmers pre-arranged for market. Farmers who fail to find buyers prefer to let their produce rot on the farm, while others stored their produce on the farm or at home until they find buyers. All the farmers harvested their fruits manually.

Postharvest activities such as sorting, cleaning, grading, transporting and storing were carried out immediately after harvest. After sorting into various sizes, the farmers had a basket that served as a standard for measuring the fruits. Depending on the size of the fruit, the price for a full basket ranged between GHC40 to GHC 60. The fruits were finally transported to the various markets for retail. Two of the farmers sold their produce directly to hotels and restaurants in Accra.



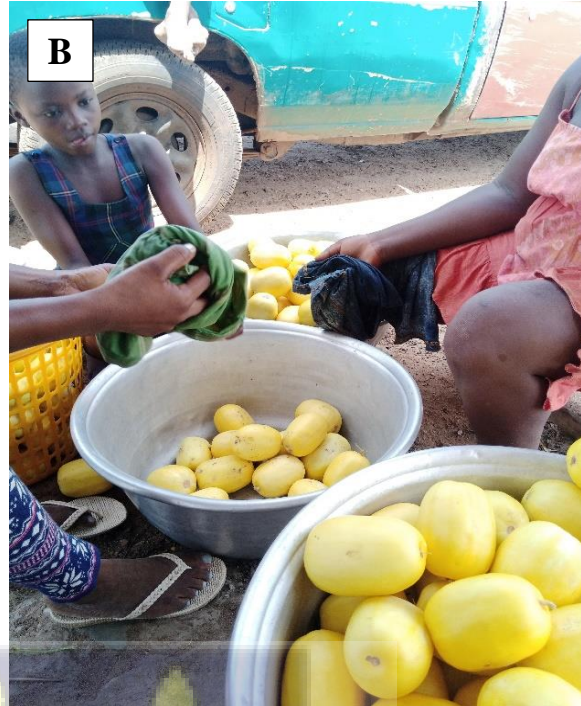


Plate: (A) Harvesting of yellow melon (B) Sorting and cleaning of yellow melon (C) Retailing yellow melon at market (D) Storage of yellow melon at the market.

#### 4.2.1 Stage of Harvest of Yellow Melon Fruit

Yellow melon fruit were harvested when half-ripened or yellow ripened. The majority (88%) of the farmers harvested their fruits when yellow ripened and 12% of them when half ripened. No farmer harvested the fruits when matured unripened or at the unripened stage (Figure 4.3).

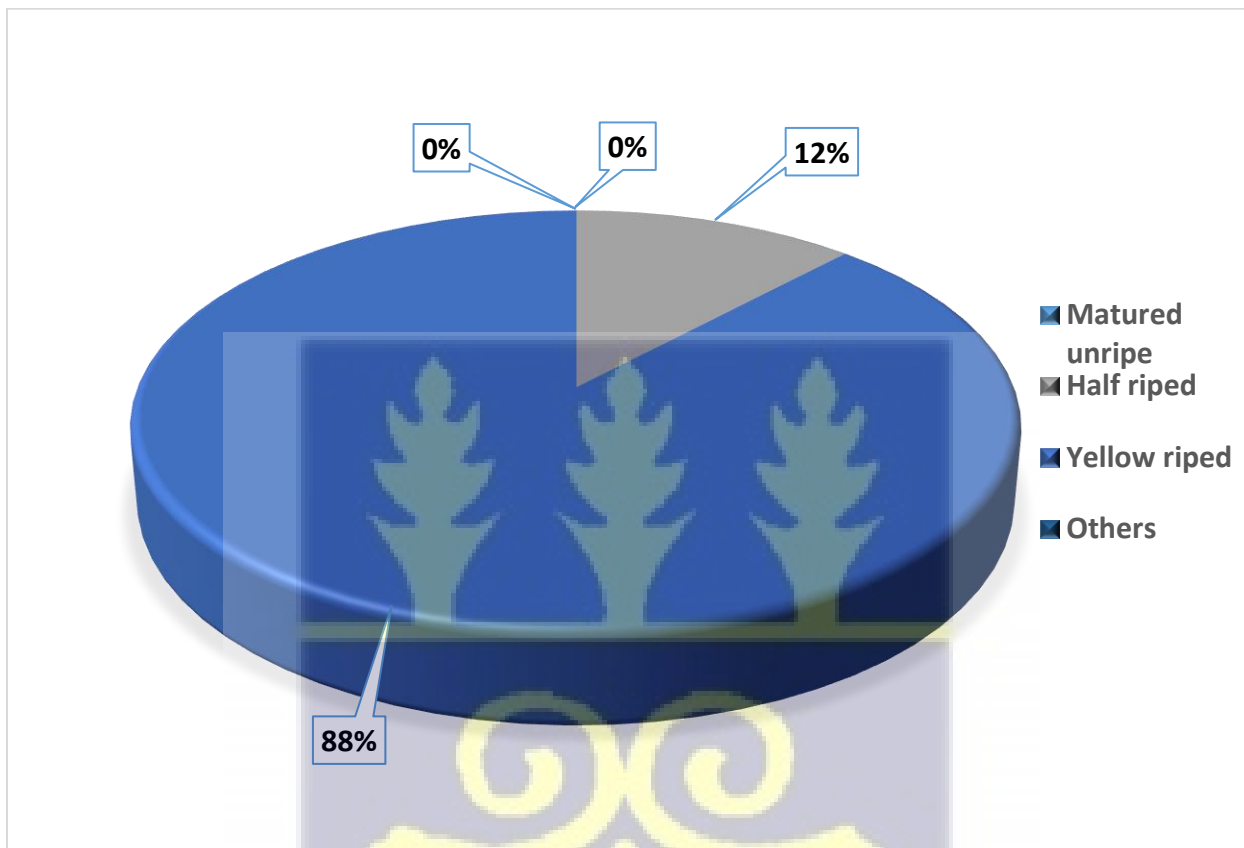


Figure 4.3 Stage of yellow melon fruit at harvest

#### 4.2.2 Packaging Material

The majority of the farmers (94%) used plastic baskets to collect the harvested fruits from the farm while only 4% used sacks for the collection of the harvested fruits.

### 4.2.3 Transportation

#### 4.2.3.1 Vehicle Used

Open trucks, van/roofed trucks and tricycles were the vehicles used by the traders to transport their yellow melon fruits to the point of sale. Thirty-eight percent (38%) of the traders transported their fruits to point of sale by the use of a van/roofed trucks, 4% by an open truck whiles 30% used tricycles. The remaining 28% did not use any vehicle but rather employed the services of head potters (Figure 4.4).

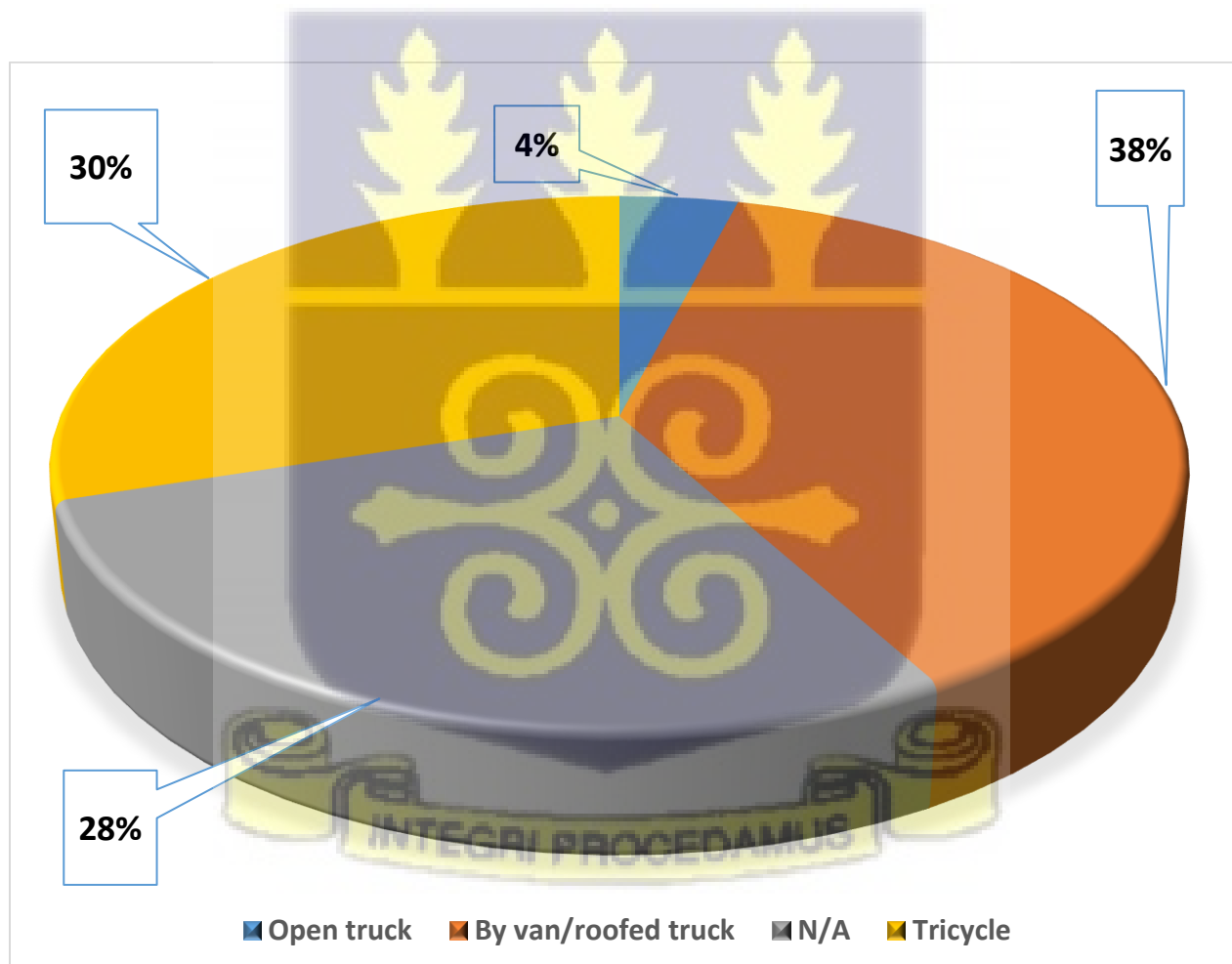


Figure 4.4 Vehicle used

#### 4.2.3.2 Materials for Covering the Fruits during Transportation

Thirty percent (30%) of the traders used rugs as materials for covering the yellow melon fruits while 2% and 28% used tarpaulin and black polythene sheets, respectively to cover their fruits.

Thirty-two percent (32%) of them did not cover their fruits during transportation (Figure 4.5).

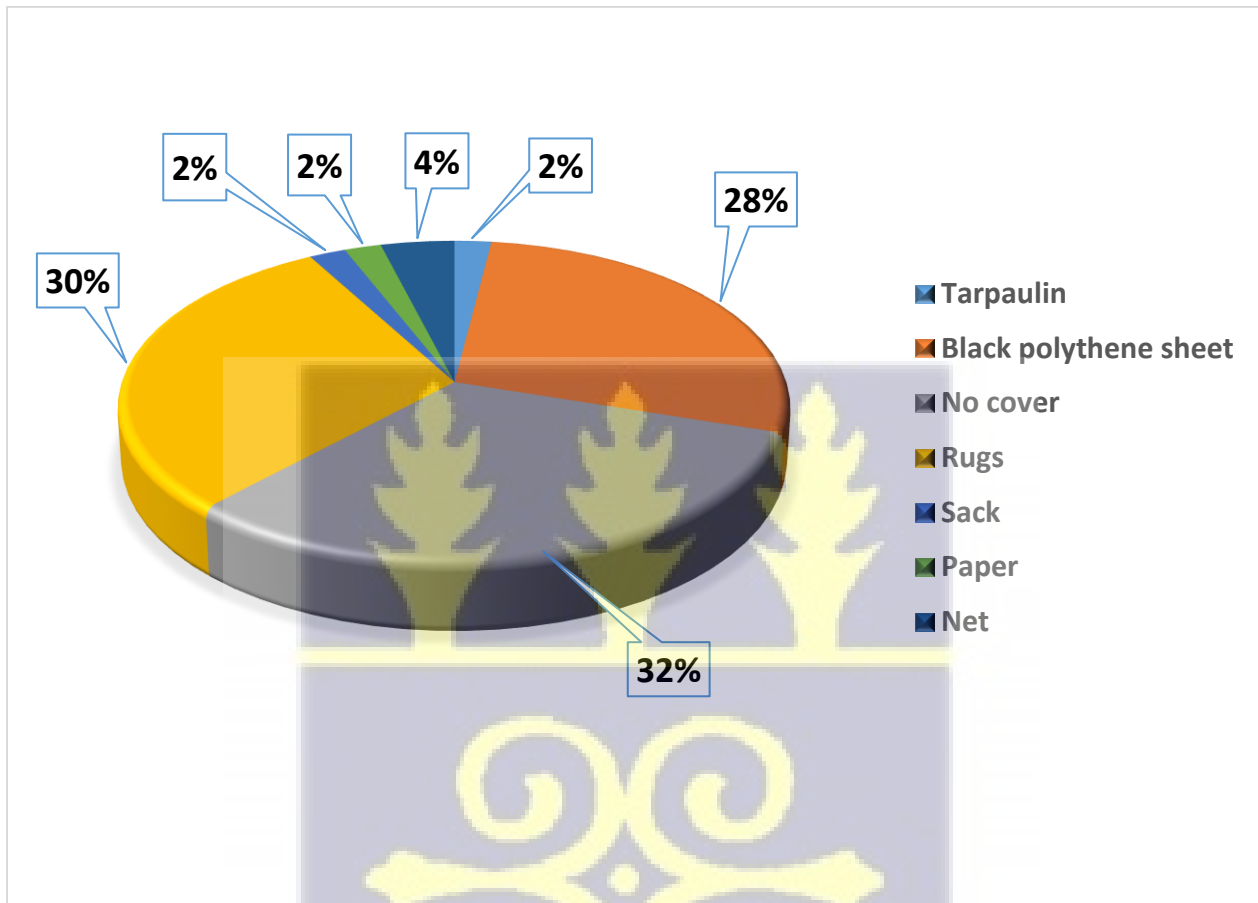


Figure 4.5 Materials for covering the fruits during transportation

#### 4.2.4.0 Storage Practices

##### 4.2.4.1 Where Farmers Store Fruits when there is no Market

Farmers in the study area were forced to store their produce on the farm or at their various homes when there was no ready market. Forty-two (42%) of the farmers stored their fruits on the farm while 30% stored the fruits in their various homes. The remaining 28% of the farmers did not harvest their fruits when there was no ready market and therefore, the fruits were left to rot on the farm.

##### 4.2.4.2 Storage Description

The farmers used different methods for storing their fruits. Nine percent (9%) of the farmers poured their fruits on black polythene sheets and covered with sacks, 30% poured the fruits on the bare floor with no covering while 16% did not harvest their produce when there were no buyers (Figure 4.6).



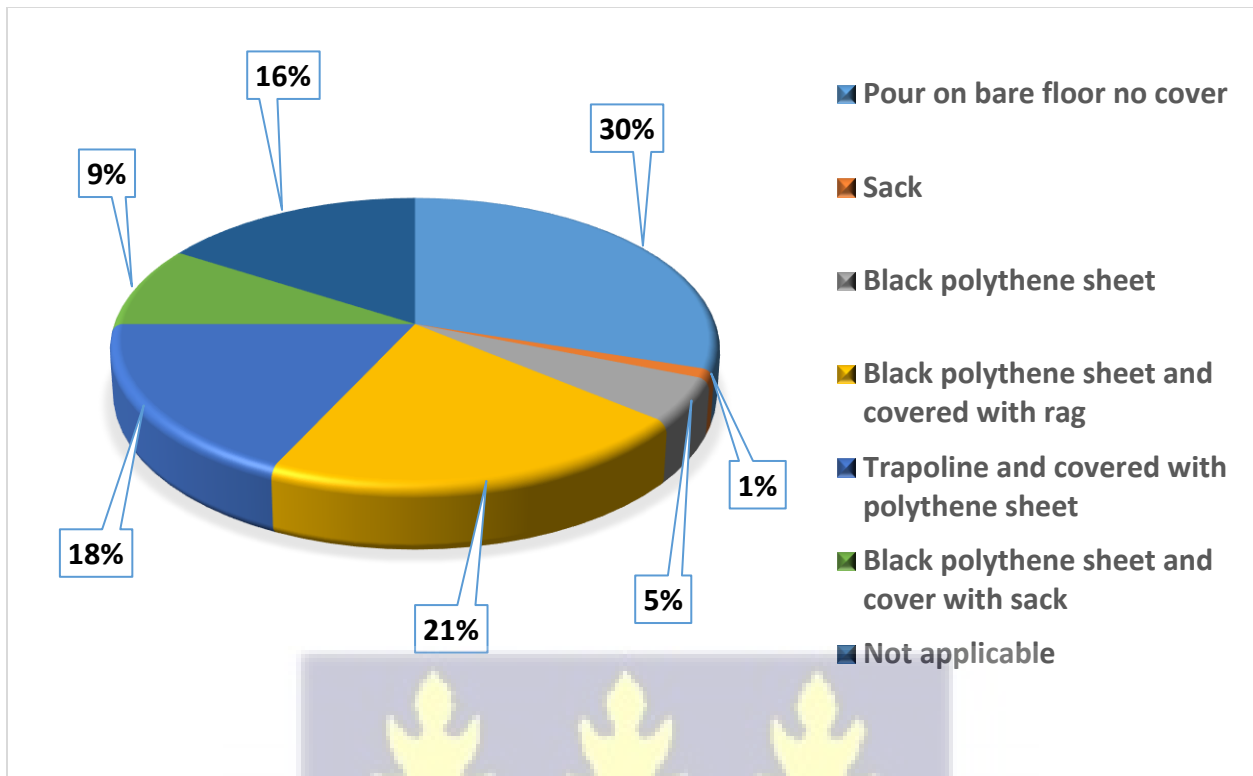


Figure 4.6 Storage description

#### 4.2.4.3 Where Traders Store Fruits

Ninty-four percent (94%) of traders stored their fruits at the market whiles the remaining six percent (6%) did not store their fruits but rather sold their fruits directly to customers at restaurants and hotels.



#### 4.2.4.4 How Traders Store Their Fruits

The traders used various means to store their fruits in the market. Two percent (2%) of the traders stored the fruits in plastic baskets and cover with rugs, 4% stored the fruits in plastic baskets cover with sacks, 12% stored the fruits in plastic baskets cover with black polythene sheets and tied with robes, while 6% did not use any of the above means (Figure 4.7).

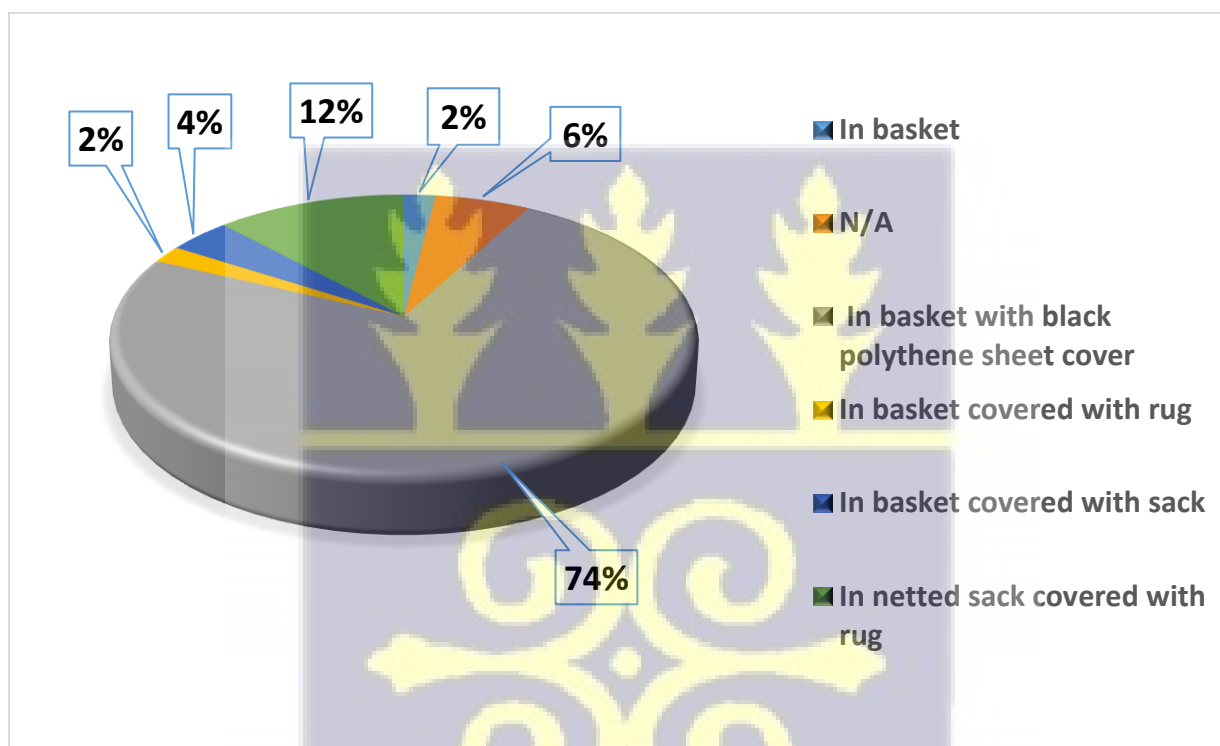


Figure 4.7 How traders store their fruits

#### 4.2.4.5 Challenges Traders Face during Storage

The challenges that were faced by the traders during the storage of the yellow melon fruits at the market included rodents' attack and rot. Twenty percent (20%) of the traders had their fruits attacked by rodents while 50% indicated their challenge was fruits getting rotten. Twenty-four

percent (24%) of the traders reported both rot and rodents attack as their major challenges. Traders who reported no challenge constituted 6% (Figure 4.8).

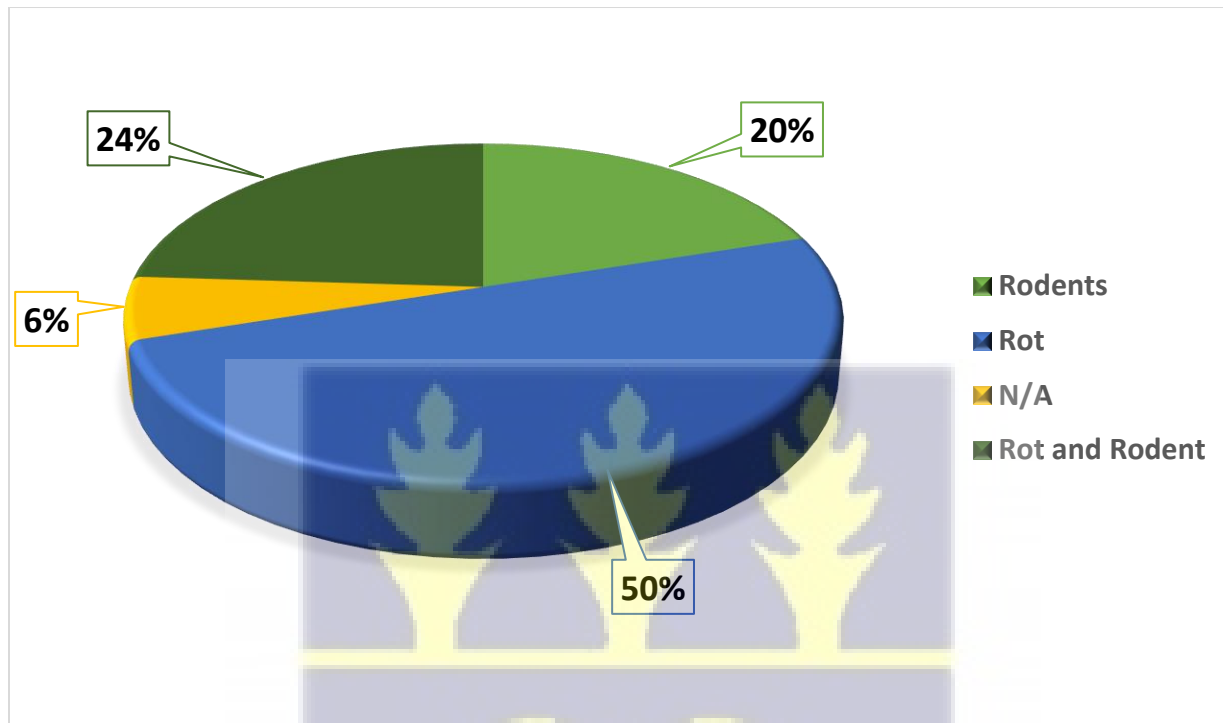


Figure 4.8 Challenges traders face during storage

#### 4.2.5 Period of Trading

The experience of the respondents in the trading business ranged from less than one year to over eight years (Figure 4.9). Fourteen percent (14%) of the traders had below one year of experience in trading. The percentage of traders who had trading experience between one to four years were 52% while 30% of them had between 5 years and 8 years of experience in trading. Four percent (4%) of the traders had been in the trading business for over eight years (Figure 4.9).

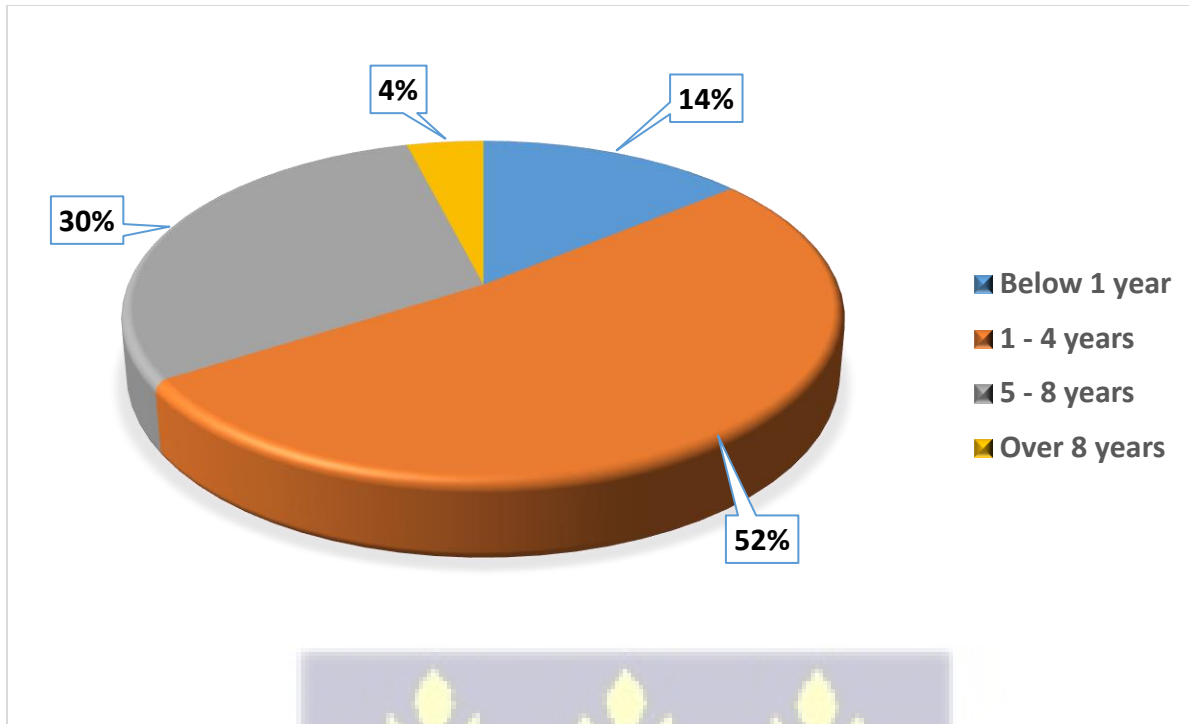


Figure 4.9 Period of trading

#### 4.2.6.0 Post-Harvest Losses

##### 4.2.6.1 Types of Losses Incurred during Harvesting and Packaging

The types of losses incurred during harvesting and packaging were categorized into mechanical, physiological and rot (Figure 4.10). Mechanical losses at harvesting and packaging were 66% and 78%, respectively. For the physiological losses, 12% occurred at harvest while 8% occurred at packaging. Twenty-two (22%) of the losses due to fruit rot occurred at harvest and 14% at packaging (Figure 4.10).



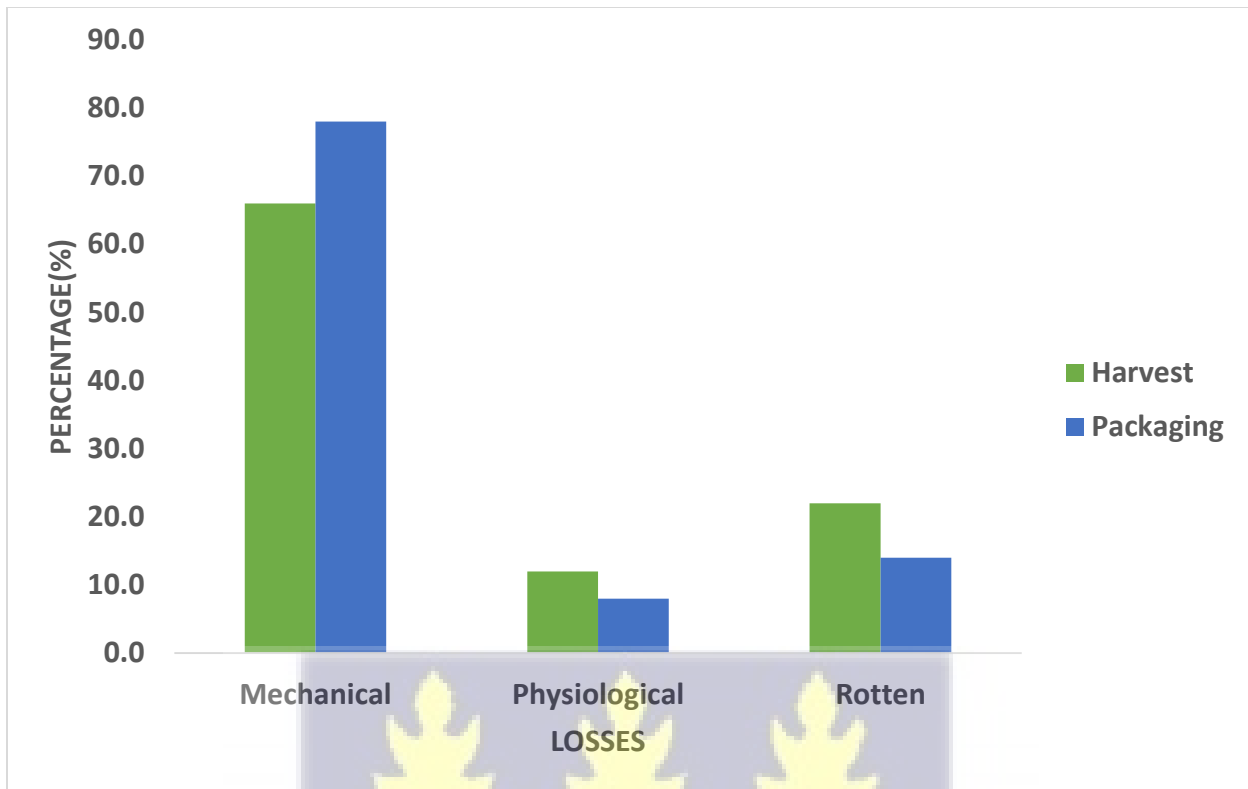


Figure 4.10 Types of losses incurred during harvesting and packaging

#### 4.2.6.2 Where Most Losses Occurred during Trading

Losses during trading mostly occurred at the point of sale, storage, and transportation. Eighty-two percent (82%) of the losses occurred at the point of sale, 4% at storage and 14% during the transportation of the fruits.

#### 4.2.6.3 Rate of Spoilage

Majority of traders representing 98% incurred very high yellow melon fruit spoilage while 2% indicated high spoilage of fruits in the sale of the yellow melon fruits.

#### 4.2.7 Estimate of losses Along the Value Chain of Yellow Melon

On an acre of land, the farmers' financial losses from yellow melon fruit at harvest ranged from GHC 50 to GHC 200, out of an estimated income of GHC 800 (Table 4.1). Eighty percent (80%) of the farmers lost GHC 150 owing to harvest losses, 14% lost GHC 200, 4% lost GHC 100, and 2% losing GHC 50.

Eighty-two percent (82%) of the farmers estimated their losses due to packaging as GHC 100 while 18% of them estimated their losses as GHC 50.

The monetary value of the losses incurred by the yellow melon farmers during storage ranged from GHC 50 to GHC 200. Eighty-four (84%) of the farmers incurred losses worth GHC 100 while, 4% incurred losses up to GHC 50. Those who lost GHC 150 due to the fruit losses were 8% while 4% of them lost GHC 200.

The highest estimate of financial losses occurred at the harvesting stage of the fruits.

On the purchase of 500 cedis worth of yellow melon fruits, the estimate of losses incurred by the traders ranged from GHC 50 and GHC 150. Thirty percent (30%) of the traders reported having incurred a loss of GHC 50 while 68% of them incurred a loss of GHC 100. The remaining 2% of the traders interviewed lost an amount of GHC 150 due to the fruit losses (Table 4.1).



Table 4.1 Estimate of losses along the value chain of yellow melon.

ESTIMATED AMOUNT(GHC)	FARMERS			TRADERS
	LOSSES AT HARVEST %	LOSSES AT PACKAGING %	LOSSES AT STORAGE%	LOSSES AT TRADE %
50	2	18	4	30
100	4	82	84	68
150	80	0	8	2
200	14	0	4	0

#### **4.2.8 Respondents Knowledge on Waxing Materials, Modern Post-Harvest Technology and Williness to Adopt Innovative Post-Harvest Technology**

Ninety-eight (98%) of farmers and all the traders did not have any knowledge about waxing

With regards to the use of waxing materials on fruits, all the respondents (both farmers and traders) did not use any waxing.

All the farmers and traders did not have any knowledge on modern postharvest technology.

They were all, however, willing to adopt modern postharvest technology.

#### **4.2.9 Help from Agricultural Extension Agents (AEAs)**

Ninety-six per cent (96%) of the farmers received extension services from the agricultural extension agents, whiles four per cent (4%) had not receive any agricultural extension services from the AEAs.

#### 4.2.10 Nature and Type of Service from AEAs

Farmers who received help on how to control pests and repair sprayers were 2%. Those who were trained on how to control weeds and how to use agrochemicals were also 2%. The percentage of farmers who were trained on diseases and pests control were 4% while those trained on the use of agrochemicals constituted 24%. Sixty-four percent (64%) of the farmers were trained on how to use agrochemicals and how to fix knapsack sprayers. Those farmers who did not receive any help or service from the agricultural extension agents constituted 4% (Figure 4.11).

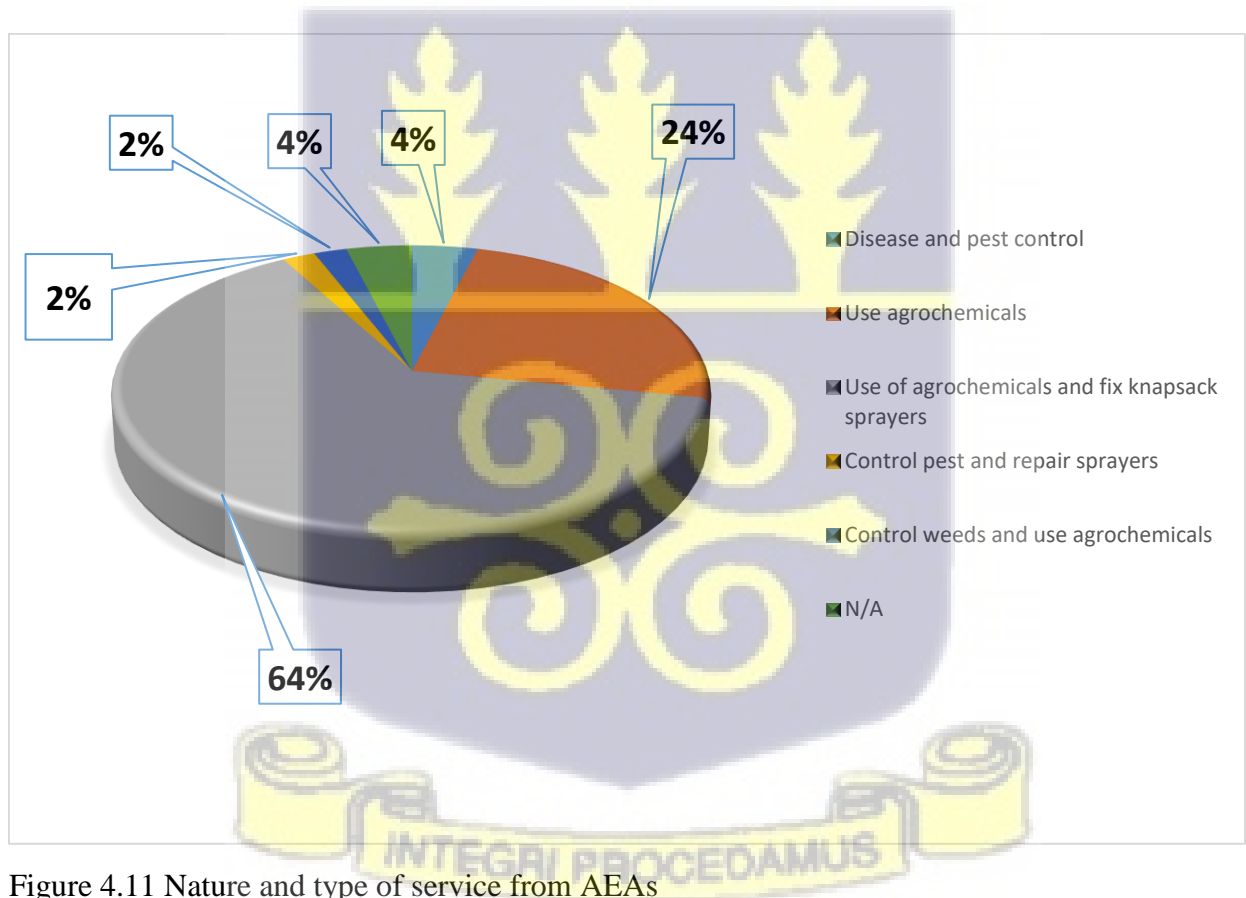


Figure 4.11 Nature and type of service from AEAs

#### **4.2.11 Effect of the Different Waxing Materials on the Physico – Chemical Attributes of Yellow Melon Fruits**

Several changes in physical, chemical, and organoleptic characteristics of yellow melon were observed following waxing treatment and length of storage.

#### **4.2.12 Effect of Waxing Materials on Percentage Weight Loss of Yellow Melon Fruits and Days of Storage.**

Generally, it was observed that as the days of storage increased weight loss of all fruits also increased (Table 4.2). Control fruits recorded the highest percentage weight loss, while fruits treated with only BW recorded the lowest percentage weight loss. There were significant difference in the percentage weight loss of all the treatments after three days of storage but then, the control fruits recorded the highest percentage weight loss followed by fruits treated with NO. Fruits treated with Bee wax only recorded the lowest weight loss followed by SB+BW treated fruits.

Significant differences were observed among percentage weight loss after six and nine days of storage. Control fruits recorded the highest value of percentage weight loss while BW recorded the lowest value.

Significant differences were also observed in the percentage weight loss after twelve and fifteen days of storage.

BW only treated fruits recorded the lowest percentage weight loss which was significantly different from the rest of the treatments.

All the fruits of the various treatments except BW only treatment got rotten before the eighteen days of storage (Table 4.2).

Table 4.2. Effect of waxing materials on percentage weight loss of yellow melon fruits and days of storage.

TREATMENT	WEIGHT LOSS (%)					
	DAYS OF STORAGE					
	3	6	9	12	15	18
CONTROL	2.91(1.85g)	10.03(3.22e)	13.42(3.73e)	0.00(0.71a)	0.00(0.71a)	0.00(0.71a)
SB	0.64(1.07c)	2.64(1.77cd)	5.66b(2.48d)	9.89(3.22f)	15.15(3.96d)	0.00(0.71a)
NO	1.12(1.27f)	3.12(1.90d)	6.47(2.64d)	11.09(3.40g)	0.00(0.71a)	0.00(0.71a)
BW	0.23(0.86a)	0.38(0.94a)	1.17(1.27a)	4.65(2.27b)	9.65(3.18b)	12.70(3.62b)
SB+BW	0.48(0.10b)	1.07(1.25ab)	1.68(1.48b)	5.47(2.44c)	12.29(3.56c)	0.00(0.71a)
SB+NO	1.00(1.23e)	2.03(1.60bcd)	4.31(2.19c)	8.72(3.04e)	0.00(0.71a)	0.00(0.71a)
NO+BW	0.76(1.12d)	1.88(1.54bc)	3.94(2.11c)	7.03(2.74d)	12.59(3.62c)	0.00(0.71a)
SB+NO+BW	0.83(1.15d)	1.49(1.41b)	4.42(2.22c)	9.62(3.18f)	0.00(0.71a)	0.00(0.71a)

The data was transformed using square root transformation.

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

#### 4.2.13 Effect of Waxing Materials on the Firmness of Yellow Melon Fruits.

Generally, it was observed that as the days of storage increased, firmness of all fruits decreased (Table 4.3). There was no significant difference in firmness of all the treatments after three days of storage, but then fruits treated with BW only recorded the highest firmness followed by fruits treated with SB+BW. The control recorded the lowest value followed by NO+BW treated fruits. Significant differences were observed for firmness among the treatments after six, nine, twelve

and fifteen days of storage. The control recorded the lowest value of firmness whiles BW recorded the highest value (Table 4.3).

All the fruits of the various treatments except BW only treatment got rotten before the eighteen days of storage.

Table 4.3 Effect of waxing materials on the firmness of yellow melon fruits.

FIRMNESS						
TREATMENT	DAYS OF STORAGE					
	3	6	9	12	15	18
CONTROL	14.13a	8.84a	0.62a	-*	-*	- *
SB	14.83a	13.02bc	7.29d	2.48b	0.64a	-*
NO	14.20a	9.51a	2.97b	0.52a	-*	-*
BW	15.72a	15.08c	14.01f	11.02d	6.09c	1.70
SB+BW	15.58a	14.81c	13.06f	9.88d	4.42b	-*
SB+NO	14.43a	11.48b	4.93c	1.25ab	-*	-*
NO+BW	15.17a	13.10bc	9.80e	4.59c	0.39a	-*
SB+NO+BW	15.40a	13.73c	6.27cd	2.07b	-*	- *

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.14 Effect of Waxing Materials on pH of Yellow Melon Fruits.

There was no significant difference in the pH of all the treatments after three days of storage but then fruits treated with SB+BW recorded the highest value of pH followed by SB+NO+BW.

Control fruits recorded the lowest value followed by NO only treated fruits.

No significant differences were observed in the values of the pH of all the treatments at six and nine days after storage but the control fruits recorded the highest value of pH.

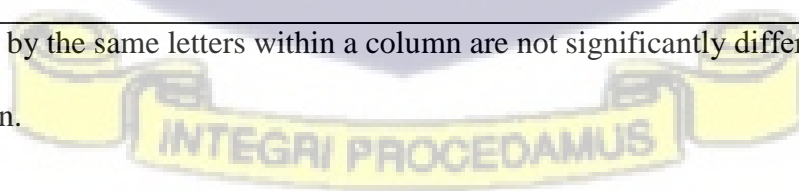
At twelve days after storage, significant differences were observed in the values of the pH. The highest pH value was recorded with fruits treated SB + BW only followed by SB+NO (Table 4.4).

Table 4.4 Effect of waxing materials on pH of yellow melon fruits.

TREATMENT	pH					
	DAYS OF STORAGE					
	3	6	9	12	15	18
CONTROL	5.96a	6.79a	6.11a	-*	-*	-*
SB	6.27a	6.46a	6.16a	6.26cd	6.57a	-*
NO	6.17a	6.42a	6.39a	5.94ab	-*	- *
BW	6.23a	5.95a	6.21a	6.11bc	6.12a	6.20a
SB+BW	6.54a	5.99a	6.30a	6.55d	6.27a	-*
SB+NO	6.35a	6.75a	6.30a	6.33d	-*	-*
NO+BW	6.38a	6.60a	6.31a	5.98ab	6.42a	- *
SB+NO+BW	6.42a	6.31a	6.39a	5.84a	-*	-*

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.



#### 4.2.15 Effect of Waxing Materials on Total Soluble Solids (TSS) of Yellow Melon Fruits.

At three, six and nine days of storage, no significant differences were observed in the the TSS. Fruits treated with NO+BW recorded the highest TSS at day six. Significant differences were observed in TSS at twelve days after storage. SB+BW treated fruits recorded the highest TSS value and NO+BW treated fruits recorded the lowest value of TSS (Table 4.5).

Table 4.5 Effect of waxing materials on total soluble solids (TSS) of yellow melon fruits.

TREATMENT	TOTAL SOLUBLE SOLIDS						
	DAYS OF STORAGE						
	3	6	9	12	15	18	
CONTROL	6.25a	6.43a	5.30a	_*	_*	_*	
SB	6.00a	6.85a	4.85a	4.42a	4.33a	_*	
NO	5.37a	6.63a	4.65a	4.30a	_*	_*	
BW	6.70a	5.40a	4.95a	3.97a	4.33a	6.03	
SB+BW	6.75a	6.20a	4.85a	5.30b	4.05a	_*	
SB+NO	7.23a	5.82a	5.75a	5.17b	_*	_*	
NO+BW	6.40a	7.12a	5.52a	3.40a	4.55a	_*	
SB+NO+BW	5.70a	5.55a	6.70a	5.28b	_*	_*	

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.16 Effect of Waxing Materials on Titratable Acidity of Yellow Melon Fruits.

There was no significant difference in the values of the titratable acidity of after three days of storage however, fruits treated with SB+NO recorded the highest titratable acidity whiles Bee wax only treated fruits recorded the lowest value.

Bee wax treated fruits had the highest titratable acidity after six days of storage and this was significantly different from the control and the fruits treated with SB, SB+NO, NO+BW.

Significant differences were observed in the titratable acidity after twelve and fifteen days of storage. The highest value was recorded for fruits treated with SB+NO+BW and this was significantly different from the rest of the treatments except SB+NO at day twelve. NO+BW treated fruits recorded the highest titratable acidity value at day fifteen which was significantly different from the rest of the treatments (Table 4.6).

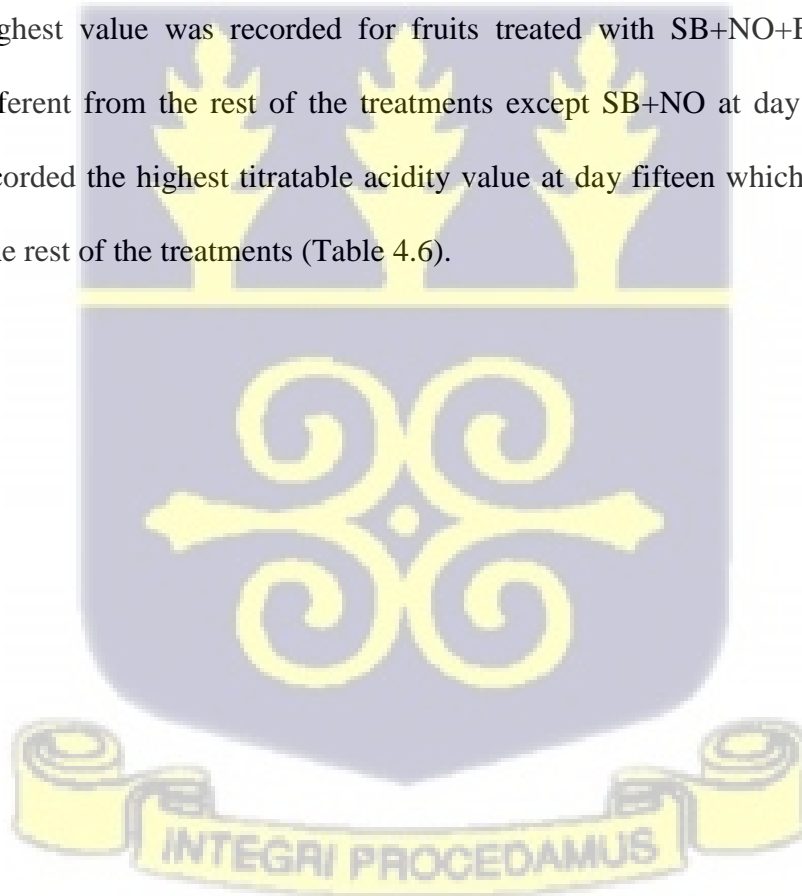


Table 4. 6 Effect of waxing materials on titratable acidity of yellow melon fruits.

TITRATABLE ACIDITY (%)						
TREATMENT	DAYS OF STORAGE					
	3	6	9	12	15	18
CONTROL	72.58a	67.24ab	66.17a	.*	.*	.*
SB	62.97a	46.96a	46.96a	36.29b	32.02a	.*
NO	70.44a	84.32bc	49.10a	50.16b	.*	.*
BW	61.91a	105.67c	49.10a	37.36b	48.03b	40.56
SB+BW	74.71a	86.45bc	49.10a	61.91b	45.90b	.*
SB+NO	87.52a	69.38ab	68.31a	92.86c	.*	.*
NO+BW	85.39a	73.65ab	57.64a	10.25a	51.23c	.*
SB+NO+BW	72.58a	67.24ab	49.10a	96.06c	.*	.*

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.17 Effect of Waxing Materials on Vitamin C Content of Yellow Melon Fruits.

BW had the highest vitamin c content which was significantly different from the rest of the treatments except fruits treated with SB+NO at four days after storage.

At eight and twelve days of storage, the vitamin C content of fruits treated with BW recorded the highest value which was significantly different from the rest of the treatments. The control had the lowest vitamin C content.

Table 4.7 Effect of waxing materials on Vitamin C content of yellow melon fruits.

VITAMIN C				
DAYS OF STORAGE				
TREATMENT	0	4	8	12
CONTROL	22.96a	10.66a	5.01a	-*
SB	22.96a	15.41a	11.14c	5.18ab
NO	22.96a	13.12a	7.88b	3.86a
BW	22.96a	22.32c	17.95d	16.14c
SB+BW	22.96a	11.16a	7.01ab	4.69ab
SB+NO	22.96a	21.32bc	12.41c	7.13b
NO+BW	22.96a	14.43a	7.38ab	4.11ab
SB+NO+BW	22.96a	16.07ab	11.16c	6.10ab

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.



#### **4.2.18 Effect of Different Waxing Material on the Sensory Attributes Of Yellow Melon Fruits**

#### **4.2.19 Effect of Waxing Materials on the Skin Colour of Yellow Melon Fruits.**

Fruits treated with SB+BW had the lowest skin colour score which was significantly different from the rest of the treatments at day 0. At day four, the control fruits recorded the lowest skin colour score which was significantly different from the rest of the treatments.

Fruits treated with BW, SB+BW and NO+BW recorded the highest skin colour score but this was not significantly different from those recorded in fruits treated with SB, NO and SB+NO+BW.

At day eight, fruits treated with BW recorded the highest skin colour score which was significantly different from the control and fruits treated with SB+BW but then it was not significantly different from the rest of the treatments.

There was a significant difference in the skin colour score of the fruits among the various treatments at twelve days after storage. BW treated fruits had the highest skin colour score which was significantly different from fruits treated with SB+BW (Table 4.8).

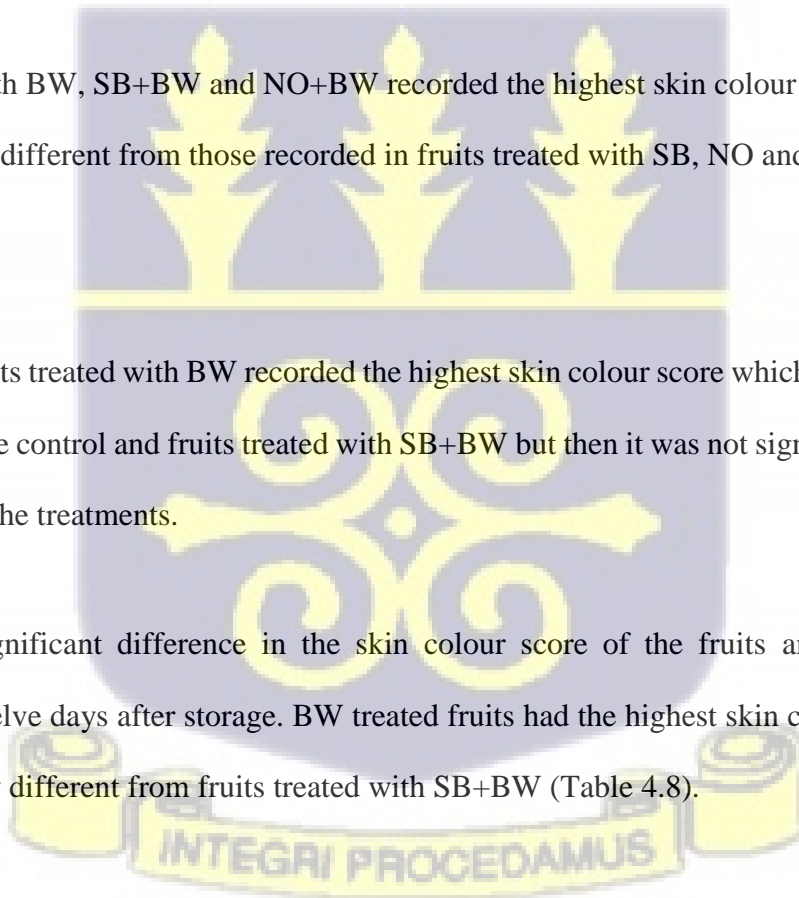
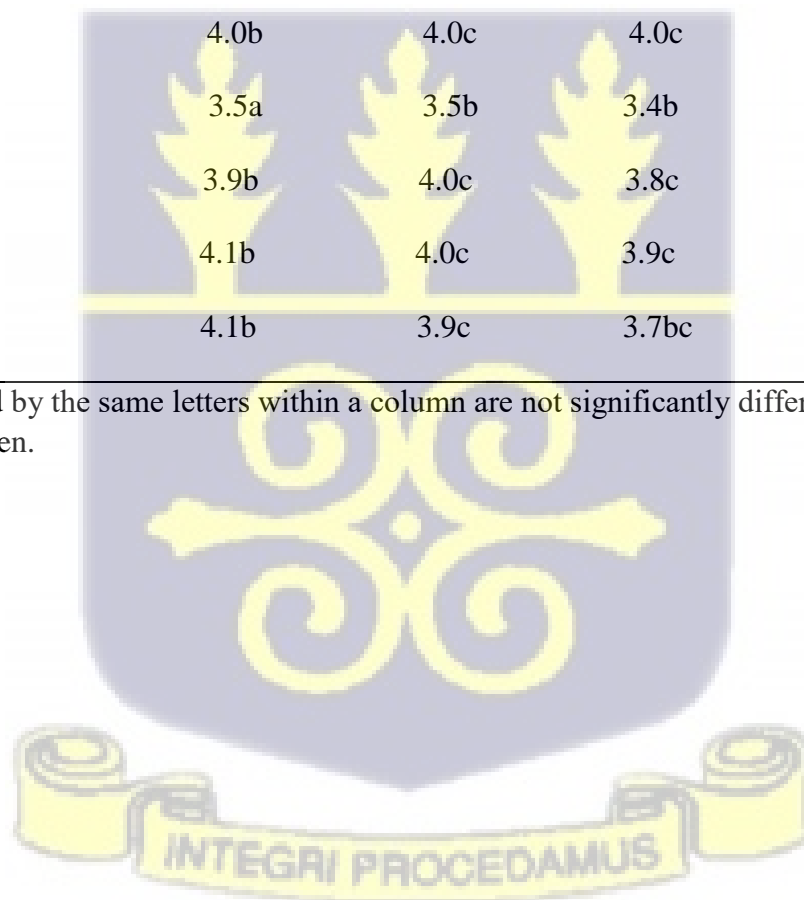


Table 4.8 Effect of waxing materials on the skin colour of yellow melon fruits.

TREATMENT	SKIN COLOUR			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	4.0b	3.2a	3.0a	-*
SB	3.9b	3.9c	3.9c	3.7ab
NO	4.0b	3.8c	3.7bc	3.5ab
BW	4.0b	4.0c	4.0c	3.9b
SB+BW	3.5a	3.5b	3.4b	3.4a
SB+NO	3.9b	4.0c	3.8c	3.7ab
NO+BW	4.1b	4.0c	3.9c	3.7ab
SB+NO+BW	4.1b	3.9c	3.7bc	3.6ab

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.



#### 4.2.20 Effect of Waxing Materials on the Texture of Yellow Melon Fruits.

At day zero after storage, no significant differences among the texture score of the treatments were observed. Significant differences were however observed among the texture scores of all the treatments at day four, eight and twelve after storage.

Fruits treated with BW recorded the highest texture score while the control fruits had the lowest texture score (Table 4.9).

Table 4.9 Effect of waxing materials on the texture of yellow melon fruits.

TREATMENT	TEXTURE			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	3.0a	3.2a	2.8a	_*
SB	3.0a	3.7a	3.7b	3.4a
NO	3.0a	3.3a	3.3b	3.1a
BW	3.0a	4.3b	4.3c	4.0b
SB+BW	3.0a	3.6a	3.6b	3.3a
SB+NO	3.0a	3.6a	3.6b	3.3a
NO+BW	3.0a	3.5a	3.5b	3.3a
SB+NO+BW	3.0a	3.4a	3.4b	3.1a

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.21 Effect of Waxing Materials on the Taste of Yellow Melon Fruits

The taste scores of the fruits under the various treatments were significantly different from the control at day zero. Control fruits recorded the highest taste score but this value was not significantly different from the rest of the treatments except those fruits treated with SB and NO at four days after storage.

At day eight and twelve, BW treated fruits recorded the highest taste which was significantly different from the taste score of fruits treated with SB and NO.

Table 4.10. Effect of waxing materials on the taste of yellow melon fruits.

TREATMENT	TASTE			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	3.6b	3.2c	2.6ab	.*
SB	2.8a	2.6ab	2.4a	2.3a
NO	2.7a	2.5a	2.4a	2.3a
BW	3.1a	3.0c	3.0b	3.0b
SB+BW	3.1a	3.0c	2.9b	2.8b
SB+NO	3.0a	3.0c	2.7ab	2.6ab
NO+BW	3.1a	3.0c	2.7ab	2.6ab
SB+NO+BW	3.1a	2.9bc	2.6ab	2.6ab

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.22 Effect of Waxing Materials on Pulp Colour of Yellow Melon Fruits.

At day 0, BW treated fruits had the highest pulp colour score and this was significantly different from the rest of the treatments except the NO treated fruits.

Significant differences were also observed in the pulp colour among the treatments after eight days of fruit storage. The highest pulp colour score was recorded in all the treated fruits and this value was significantly different from that of the control fruits.

There was no significant difference in the pulp colour among all the treatments at four and twelve days after fruit storage.

Table 4.11 Effect of waxing materials on pulp colour of yellow melon fruits.

TREATMENT	PULP COLOUR			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	3.1a	3.0a	2.2a	_*
SB	3.0a	3.0a	3.0b	3.0a
NO	3.4b	3.0a	3.0b	3.0a
BW	3.5b	3.0a	3.0b	3.0a
SB+BW	3.0a	3.0a	3.0b	3.0a
SB+NO	3.0a	3.0a	3.0b	3.0a
NO+BW	3.0a	3.0a	3.0b	3.0a
SB+NO+BW	3.0a	3.0a	3.0b	3.0a

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.23 Effect of Waxing Materials on Mouth Feel of Yellow Melon Fruits.

The mouth feel scores of the fruits under the various treatments were significantly different from the control and fruits treated with BW only at day zero, four and twelve days after storage. At day eight, except for control fruits, the mouthfeel score for the rest of the treatments were not significantly different.

Table 4.12 Effect of waxing materials on mouth feel of yellow melon fruits.

TREATMENT	MOUTH FEEL			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	3.6b	3.0ab	2.0a	.*
SB	3.0a	3.0ab	2.7b	2.7b
NO	2.9a	2.7a	2.5ab	2.3a
BW	3.8b	3.5c	3.0b	3.0b
SB+BW	3.1a	3.1b	3.0b	3.0b
SB+NO	2.8a	2.8ab	2.8b	2.7b
NO+BW	3.1a	3.1b	3.0b	3.0b
SB+NO+BW	2.9a	2.8ab	2.8b	2.8b

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.24 Effect of Waxing Materials on the Glossiness of Rind of Yellow Melon Fruits.

At day zero, four and eight, significant differences were observed in the glossiness of the rind among the treatments.

SB+BW treated fruits recorded the highest rind glossiness score at day zero and eight. The fruits with the highest rind glossiness were recorded in SB+NO and NO+BW treated fruits at four and twelve days after storage. Control fruits recorded the lowest rind glossiness.

Significant differences were again observed in the glossiness of the rind of the treatments after twelve days of storage. SB treated fruits recorded the lowest rind glossiness (Table 4.13).

Table 4.13 Effect of waxing materials on the glossiness of rind of yellow melon fruits.

TREATMENT	GLOSSINESS OF RIND			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	2.6a	1.7a	1.4a	.*
SB	3.4b	3.0c	2.8b	2.6a
NO	3.1ab	3.0c	2.8b	2.7ab
BW	2.7a	2.6b	2.9b	2.9ab
SB+BW	3.9c	3.1c	3.0b	3.0b
SB+NO	3.3b	3.2c	3.0b	3.0b
NO+BW	3.3b	3.2c	3.0b	3.0b
SB+NO+BW	3.1ab	3.0bc	2.8b	2.8ab

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.25 Effect of Waxing Materials on the Flavour of Yellow Melon Fruits.

At day 0, BW treated fruits were the most preferred flavour and this was significantly different from the rest of the treatments except the control fruits. Significant difference in flavour was also observed at day four. BW treated fruit had the best fruit flavour followed by control fruits.

At day 8, BW treated fruits recorded the highest score for flavour and it was significantly different from the rest of the treatments.

Again at twelve days of fruit storage, a significant difference existed among the flavour scores of all the treated fruits (Table 4.14).

Table 4.14 Effect of waxing materials on the flavour of yellow melon fruits.

TREATMENT	FLAVOUR			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	4.0cd	3.9de	3.0b	-*
SB	3.3ab	3.1ab	3.0b	2.9ab
NO	2.9a	2.8a	2.7a	2.6a
BW	4.3d	4.0e	4.0d	3.9d
SB+BW	3.7bc	3.6cd	3.5c	3.4c
SB+NO	3.0a	3.0a	3.0b	2.8ab
NO+BW	3.6bc	3.4bc	3.2bc	3.1bc
SB+NO+BW	3.6bc	3.4bc	3.2 bc	3.0b

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.26 Effect of Waxing Materials on Attractiveness of Rind of Yellow Melon Fruits.

Significant differences were observed in the attractiveness of the rind of the treatments in all the days after fruit storage. BW treated fruits recorded the highest score of the attractiveness of rind and this was significantly different from the rest of the treatments. Control fruits recorded the lowest score for the attractiveness of rind.

At day twelve, SB+NO treated fruits recorded the lowest score for the attractiveness of rind (Table 4.15).

Table 4.15 Effect of waxing materials on attractiveness of rind of yellow melon fruits.

TREATMENT	ATTRACTIVENESS OF RIND			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	2.9a	2.5a	2.0a	.*
SB	3.8b	3.3bc	3.0b	2.9a
NO	3.8b	3.1b	3.0b	2.9a
BW	4.6c	4.3d	3.5c	3.3b
SB+BW	3.8b	3.3bc	3.0b	3.0ab
SB+NO	4.0b	3.7c	3.0b	2.8a
NO+BW	3.8b	3.6c	3.0b	2.9a
SB+NO+BW	3.8b	3.6bc	3.0b	2.9a

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.27 Effect of Waxing Materials on Overall Acceptability of Yellow Melon Fruits.

At day 0, BW treated fruits recorded the highest score for overall acceptability and this was significantly different from the rest of the treatments except the control fruits.

There was no significant difference in the overall acceptability scores among all the treatments at twelve days after fruit storage.

Significant differences were again observed in the overall acceptability scores among the treatments after eight days of fruit storage. The highest overall acceptability score was recorded in BW treated fruits (Table 4.16).

Table 4.16 Effect of waxing materials on overall acceptability of yellow melon fruits.

TREATMENT	OVERALL ACCEPTABILITY			
	DAYS OF STORAGE			
	0	4	8	12
CONTROL	3.6b	3.0a	2.0a	-*
SB	3.1a	3.0a	3.0b	3.0a
NO	3.0a	3.0a	3.0b	3.0a
BW	3.8b	3.5b	3.2c	3.0a
SB+BW	3.0a	3.0a	3.0b	3.0a
SB+NO	3.0a	3.0a	3.0b	3.0a
NO+BW	3.0a	3.0a	3.0b	3.0a
SB+NO+BW	3.0a	3.0a	3.0b	3.0a

Means followed by the same letters within a column are not significantly different at  $p \leq 0.05$ .

\* Fruits got rotten.

#### 4.2.28 Effect of Edible Coatings on the Shelf-life of Yellow Melon Fruits

Fruits treated with BW only was able to prolong the shelf-life of the yellow melon fruits up to eighteen days and this was significantly different from the control fruits (9 days of shelf-life). Yellow melon fruits treated with SB only, SB + BW and NO + BW prolong the shelf- life of the fruits for fifteen days, respectively. For NO, SB + NO and SB + NO + BW treated fruits, they were able to prolong the shelf-life of the yellow melon fruits for twelve days (Figure 4.12).

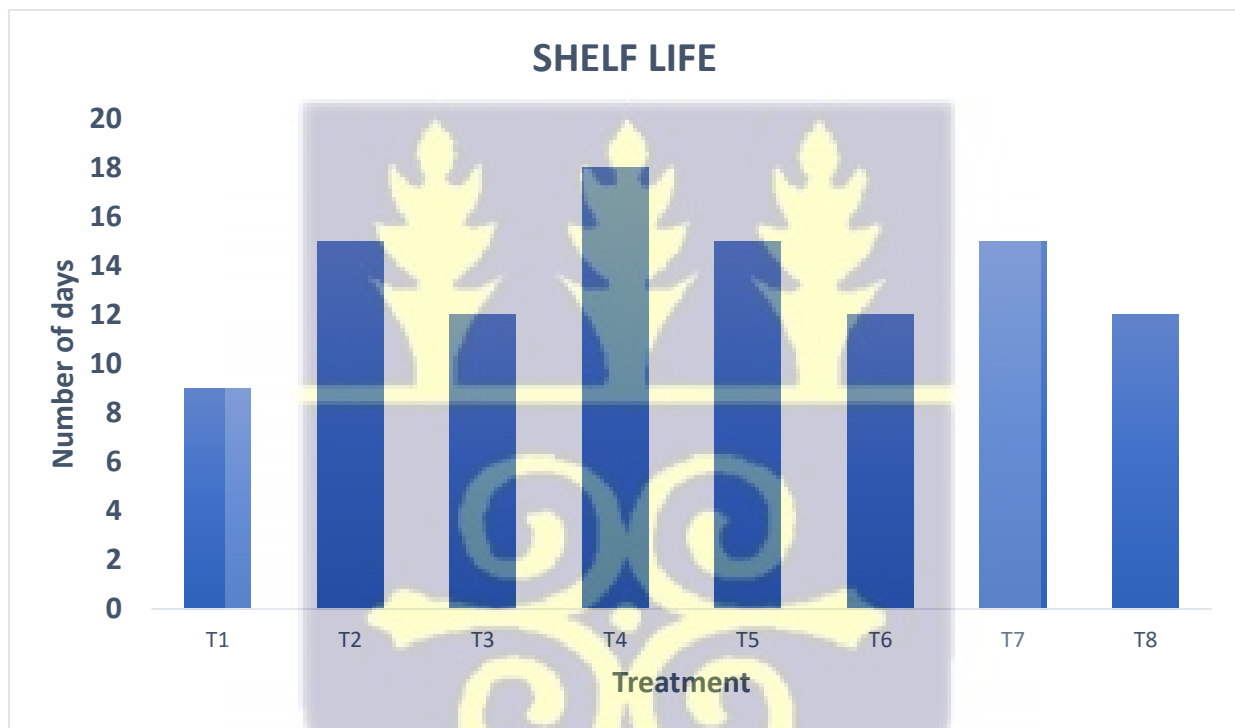
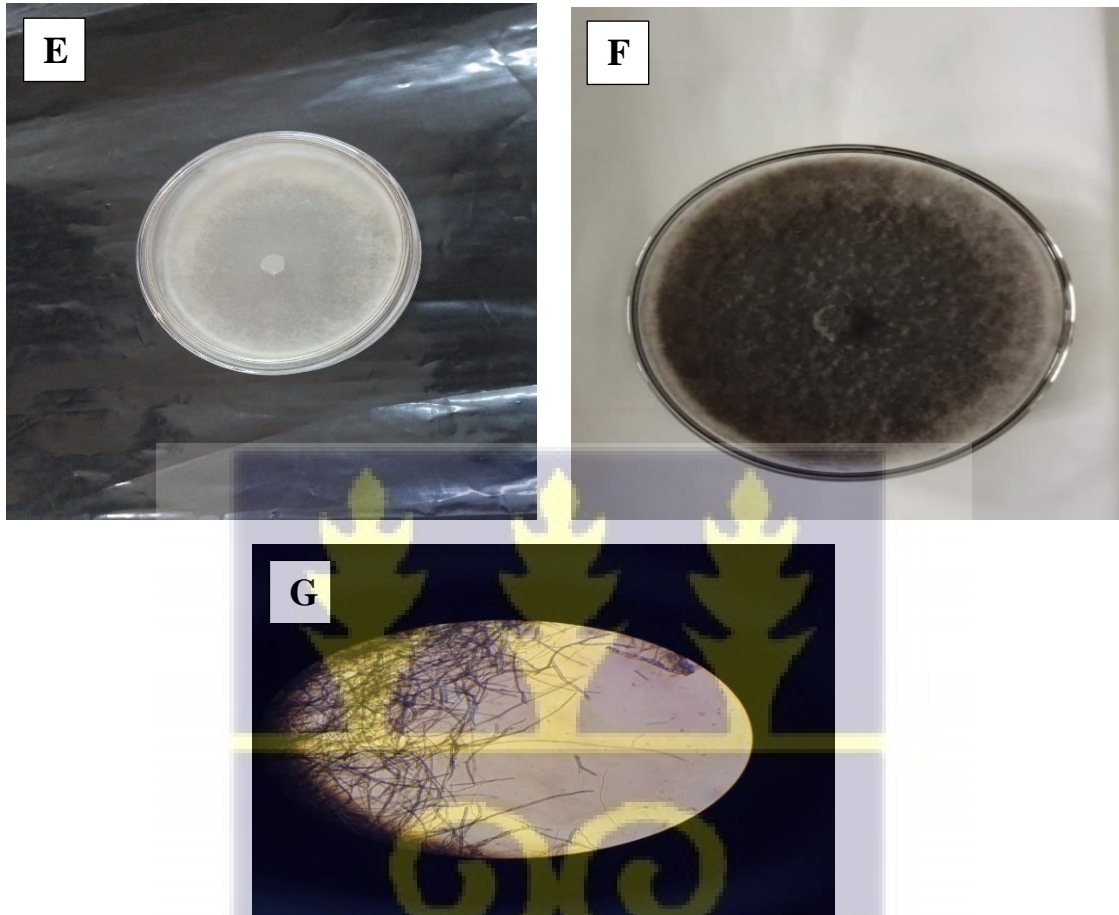


Figure 4.12 Effect of Edible Coatings on Shelf life of Yellow Melon Fruits

#### 4.2.29 Organisms Identified after Isolation

The morphological features of the isolates showed *Lasiodiplodia theobromae*. Colonies were initially white to mouse grey and eventually turned dark after 5days to 7 days on PDA (Plate F). After two weeks of culturing, globular or irregular grey *pycnidia* were observed. Immature *Conidia*

produced in *pycnidia* were initially unicellular, hyaline, granulose, subovoid to ellipsoidal while mature *conidia* became darker, uniseptate, and longitudinally striate.



Cultural and morphological features of *Lasiodiplodia theobromae* consistently isolated from rotten yellow melon fruit. Plate: (E) White to mouse gray mycelium growth on PDA; (F) Dark colonies growth on PDA; (G) Irregular grey pycnidia.

#### 4.2.30 Pathogenicity Test

All isolates of *Lasiodiplodia theobromae* used for the inoculation studies were able to induce the rot disease symptoms on the inoculated fruits. Three days after inoculation, large portions of the fruit around the point of inoculation were found to show light coloured watery portions. By the 5th day after inoculation, the lesion had darkened and the fruits were completely rotten. The disease

symptoms were not observed on the fruits inoculated with PDA only. The pathogen was re-isolated from the symptoms to complete Koch's postulates.



## CHAPTER FIVE

### 5.0 DISCUSSION

#### 5.1 Gender of Respondents

Yellow melon farming is male-dominated whilst trading or marketing of the produce is dominated by female. This result conforms to that of Adamu *et al.* (2017) on the differentials in returns of watermelon (*Citrullus lanatus*) and sweet melon (*Cucumis melon*) production among farmers in Gombe and Bauchi States, Nigeria. They reported that 97.7% of watermelon and 100% of sweet melon farmers were males while 2.3% and 0% were females, respectively. Mensah & Fosu-Mensah (2020) also reported male-domination of melon production in the Upper East Region of Ghana. The report indicated males as the major players in land preparation, seedling production and the financial administration regarding purchasing of farm inputs, farm financing and maintenance of farm records.

#### 5.2 Educational Level of Respondents

The majority of the respondents had some form of formal education. The respondents' low level of education made it difficult for them to realize that the poor postharvest handling practices they employ resulted in the losses they incurred. Rathore *et al.* (2007) reported that lack of postharvest technical knowledge among producers and traders are the cause of postharvest losses in Pakistan. Education plays a vital role in agriculture. It aids in better understanding and adaption of innovative postharvest technologies. When handlers attain a higher educational level it permits farmers and traders to have knowledge, exposure, and interest to explore more on current trends in reducing postharvest losses. Abdullah & Samah (2013) reported that the low educational level of farmers is one of the contributing factors that result in the non-adoption of agricultural technology in

Malaysia. According to Mugonola *et al.* (2013), the ability to receive, evaluate, and adopt new information is much faster with highly educated farmers than less educated.

### **5.3.0 Postharvest Handling Practices along the Yellow Melon Value Chain in Afiinya**

The fruit has high export potential therefore there is the need to cultivate quality fruits that can meet international standards. The climatic condition of the area plus the presence of an irrigation facility at is a good sign to cultivate the crop all year round.

#### **5.3.1 Pre-Arrangement for Market**

To reduce storage costs, pests attack, postharvest diseases, and effects of harsh weather conditions that result in postharvest losses, the farmers have developed a culture of pre-arranging for market before planting or harvesting. Some of the farmers explained that in instances where there were no buyers, the fruits were harvested and stored on the farm or their homes till they get buyers. Some prefer to leave their fruits to rot on the farm rather than harvesting. Fruits were left to rot on the farm due to high transportation charges and low prices traders offer them if the fruits were sent to the market. The unavailability of buyers to purchase the fruits at the farm gate leads to initial losses which affected their income.

Storing fruits at home or on the farm means the farmers must get buyers within just a week after harvesting due to the high perishable nature of the fruits and no application of postharvest treatment to extend shelf -life of fruits.

To prevent or reduce postharvest losses of the fruits, Dev (2012) suggested contract farming which has the potential to help the small and marginal farmers overcome barriers to marketing. Wang *et*

*al.* (2014), also suggested that participating in contract farming improves the welfare of those who choose to participate.

### **5.3.2 Stage of harvest of Yellow Melon Fruit**

Stage of maturity at harvest is critical to prolong shelf-life and preserve fruits quality. When fruits are harvested at the immature stage, it results in uneven ripening and poor-quality (Prasad *et al.*, 2018).

The present study showed that traders prefer purchasing fruits that are yellow riped because thoses are what their customers prefers. This informed 88% of the farmers to harvest their fruits at that stage. This corroborates Panghal *et al.* (2018) report that in most cases, buyers select fruits based only on appearance and earlier studies by Vanoli *et al.* (2015) that to put high-quality fruits on the table of the consumers, harvest time or stage play a key role to guarantee quality.

### **5.3.3 Packaging Material**

Considering the losses recorded along the value chain of fruits and vegetables, agricultural packaging is now key to the food handler. Apart from the type of materials used to produce the packaging material, the packaging material must meet all or most of the packaging requirements to assure quality produce. The common packaging materials used by the rural farmer include; wooden boxes, sacks, plastic bowls, plastic and cane baskets. In this study, 94% of the farmers used plastic baskets for collecting and packaging the fruits. This same basket was used as a standard for measuring the fruits during sale thus making it easier for pricing. Plastic baskets are sturdy, durable, highly aerated, washable and can be reused many times if handled properly. Best results are achieved when the baskets are cushioned with soft material to reduce impact during handling and transportation. Throwing fruits into baskets and overloading should be avoided to

reduce bruises, which result in losses. The remaining 4% used nylon sacks. Nylon sacks are considered a poor packaging medium for fresh produce. The use of nylon sacks has great potential to accelerate postharvest losses because of their low ability to protect the fresh produce from harsh environmental and handling conditions along the value chain. Hurst *et al.*, (2010) suggested that, in the packaging of fresh food crops, nylon sacks should be avoided since aeration in nylon sacks is poor, resulting in the build-up of heat due to respiration.

#### **5.3.4.0 Transportation of Fruits**

##### **5.3.4.1 Vehicle Used**

Fresh fruits and vegetables are highly perishable and any delay from the farm to the retail point can result in huge losses. Murthy *et al.* (2009) reported that along the supply chain of perishables, the highest and major causes of losses are recorded during transportation. According to Babarinsa *et al.* (2018), Nigeria loses 10% and 40% of its revenue when moving fresh fruits and vegetables from farms to collection centers and then to markets, and these losses result in environmental waste management concerns. Open truck, van/roofed truck and tricycle were the vehicle used by the traders to transport their yellow melon fruits to the point of sale in this study. All these vehicles employed for transporting the produce were not designed to protect the fresh produce from the harsh weather and other environmental factors, thereby, contributing greatly to postharvest losses during movement from the farm gate to the sale point. It is against this background that Khan & Jan (2007) suggested that to reduce postharvest losses, fruits and vegetables should be transported by appropriate vehicles and packaging systems.

The presence of specialized temperature control vehicles, good road network and good handling practices throughout transportation can significantly reduce postharvest losses.

#### **5.3.4.2 Materials for Covering the Fruits during Transportation**

To protect and provide shade for fresh fruits and vegetables from the harsh sun, rain, wind, and other environmental factors, farmers and traders used various materials to cover their fruits during transportation. Ait-Oubahou *et al.* (2019) reported that when fresh produce is exposed to the sun, the temperature rises and results in solar injuries. The authors added that the produce loses water when exposed to excessive airflow. In this study, black polythene sheets, tarpaulin, nets, sacks, and papers were used by the handlers for covering the fruits during transportation. The majority of them (32%) did not cover their fruits at all thereby, exposing the fruits to the harsh weather condition. The use of net by some of them was only able to prevent the fruits from dropping off the truck rather than protecting them from environmental conditions. The use of black polythene sheets, nylon sacks, and tarpaulin can only protect the fruits from rain and dust but will encourage the buildup of heat to accelerate postharvest losses. This finding is in line with that of Lamptey (2013), who reported that when tarpaulin, both plain (transparent) and black polythene sheets are used to cover fruits during transportation heat is trapped causing deterioration.

#### **5.3.5.0 Storage Practices**

Poor storage practices is among the major challenges faced by both farmers and traders. In this study, the only place farmers stored their fruits if there was no market was either on the farm or designated places at home. Considering melon fruit's short shelf-life coupled with the absence of storage facilities and processing facilities in the study area, handlers are usually in a haste to sell the fruits for fear of subjecting the fruits to rapid rotting. These findings support that of Robert *et al.* (2014), who identified lack of storage facilities as the most essential and critical challenge faced by tomato growers in Offinso North District. Previous studies by Nath & Sil (2008) showed that

lack of storage facilities for fresh fruits and vegetables in rural areas compels farmers to adopt distress sale of the produce after harvest.

The farmers employed various methods in storing their fruits. Pouring on the floor with covering or no covering was the most common practice among the farmers. These traditional ways of storage contributed significantly to postharvest losses of the fruits. According to Basediya *et al.* (2013), large-scale losses during storage and transportation is linked to farmers and traders practicing traditional methods.

#### **5.3.5.1 Where Traders Store Fruits and Challenges Faced**

Majority of the traders (94%) store their fruits at the market. The traders preferred keeping their fruits at the market because of the cost involved in moving the fruits from other places to the market daily. Market authorities not providing specialized storage facilities to the traders exposes the fruits to mechanical and physiological losses as well as rodent attacks. This has made the traders employ various means to store their fruits at the market.

At the close of the day, traders placed their fruits on the table, cover with black polythene sheet then tie it with ropes. This method is however not able to keep the fruits safe because of pest and rodent attack as well as heat build-up that accelerates spoilage. According to Hengsdijk & de Boer (2017), rodents and other pests cause significant postharvest losses to agricultural produce.

#### **5.3.6.0 Postharvest Losses**

Postharvest losses are recorded throughout the supply chain of horticulture crops. These losses do not only deny the consumer of the quality required and nutrients packed in the fruit but also economic loss to handlers of the produce.

### **5.3.6.1 Types of Losses Incurred**

Maturity time at harvest, harvesting method, containers for collecting fruit during harvesting are factors that can contribute to losses at harvest. At harvest, the farmers recorded mechanical and physiological losses as well as fruit rot. Up to 66% mechanical loss at harvest was reported by the respondents. The high percentage recorded can be attributed to the fact that the farmers harvested their fruits yellow rip and also toss the yellow riped fruit into non - cushion collecting bins, thereby subjecting the fruits to mechanical damage. Good handling practices at harvest are therefore key in minimizing mechanical losses. Banjaw (2017) recommended that during harvesting, care must be taken to minimize mechanical damage such as scratches, cuts, punctures and bruises. He also suggested that farmers should not harvest immature or over ripe fruits and harvesting should be done during the coolest part of the day (morning and late evening). At packaging, 78% mechanical losses were recorded.

### **5.3.6.2 Where Most Losses Occurred during Trading**

At the sale point traders (82%) recorded losses and the rate of spoilage was up to 98%. The losses can be attributed to the short shelf-life of the fruits, which necessitates gentle care during handling. The absence of storage facilities in our markets is also another key constraints. This finding agrees with that of Rathore *et al.* (2007) that up to about 40% losses in fruits in Pakistan are as a result of mishandling, inadequate storage, or lack of postharvest technical knowledge among producers and traders.

### 5.3.7 Estimate of Losses

The study showed that along the value chain of the yellow melon in Afienya, economic losses were recorded at harvest and after harvest. The total economic loss incurred by the farmers was estimated as GH¢ 17, 500 out of an expected income of GH¢ 80,000. While that of the traders was GH¢ 4,300 out of an expected income of GH¢ 15,000. Losses recorded included physiological, mechanical, rot, and rodents attack. These losses were as a result of the absence of storage facilities, lack of information on postharvest management practices, lack of pest's control, and poor handling practices along the value chain. Similar observations were made by Lamptey (2013), who identified insects and rodents attack, dropping and cracking during loading, transportation, and off-loading operations, and rot due to diseases as the principal causes of postharvest losses of watermelon.

### 5.4.0 Help from Agricultural Extension Agents (AEAs) and Nature of Service

The primary function of extension workers especially in the rural farming communities is to disseminate information and encourage farmers to adopt innovative technology that may not be readily available or accessible to them (Suvedi *et al.*, 2017). It was observed in this study that the majority of the farmers (96%) had access to extension services. Insect pests and weeds control, use of agrochemicals, and fixing of faulty knapsack sprayers were among the training given to the farmers. However, it was observed that the extension workers did not educate the farmers on postharvest handling practices. When farmers are educated on innovative and cost-effective methods of handling produce after harvest, it is very likely farmers will be able to extend the shelf-life of fruits and also provide quality fruits to meet export requirements. Azikiwe *et al.* (2013), reported that farmers readily adopt quality extension services thereby increasing agricultural productivity and farmers' income.

### 5.5.0 Effect of Waxing on the Quality Changes of Yellow Melon Fruit

#### Percentage Weight Loss (% WL)

Physiological processes such as respiration and transpiration resulting in weight loss are usually high in fresh fruits and vegetables stored at tropical ambient conditions. The period of storage also plays a vital role in weight loss. Since most fresh produce are usually sold based on weight, weight loss influences the economic value and consumer acceptability of the fruit.

In this study, it was observed that as days of storage progresses, waxing materials were able to limit weight loss in coated fruits compared with the uncoated control fruits. This finding is consistent with the report of other studies to emphasize the importance or benefits of waxing. Chen *et al.* (2019) observed that coating jujube fruit with carnauba wax can reduce weight loss by forming a semi-transparent layer on the pericarp that acts as a physical barrier to moisture loss. Shahid & Abbasi (2011b), hypothesized that the beeswax coats reduced the fruit's respiration rate, lowered weight loss and extended the shelf- life of sweet oranges. Khaliq *et al.* (2017) reported that chitosan coatings were able to seal the stomata of mango fruits thus minimizing moisture loss and weight loss. Gupta & Jain (2014) reported that the application of neem plant extract significantly reduced weight loss and maintained the postharvest quality of mango fruit during storage.

#### 5.5.1 Firmness

According to (Ozturk *et al.*, 2012), fruit firmness is a key quality index in determining shelflife and fruit market value. Fruits are usually purchased based on appearance and texture (Nayik & Muzaffar, 2014; Nayik *et al.*, 2015). A decrease in the turgor pressure and crispness of fresh fruits is a result of fruit textual changes caused by water loss (Yang *et al.*, 2014).

The study revealed that fruit firmness decreased in all treatments during storage. A decrease in fruit firmness was higher in uncoated control fruits than in wax-coated fruits. The change in fruit firmness with BW-only treated fruits was lower than with the other treatments. The waxing materials applied to the fruits were able to reduce excessive moisture loss of the fruit thereby, maintaining the firmness of the fruits compared to the control fruits.

The above finding corroborate with that of Eshetu *et al.* (2019) who investigated the effect of beeswax and chitosan treatments on quality and shelf- life of selected mango. The authors found that, the application of 2% beeswax was the most successful treatment, resulting in higher firmness throughout the storage period. Dávila-aviña *et al.* (2011) reported that firmness was higher in tomato fruits treated with mineral oil wax or carnauba wax than uncoated control fruits. They explained that wax coating prevents moisture loss by creating barriers between the fruit and environment, can retain better cell turgidity, and also produce fruit with more firmness than the control. Bill *et al.* (2014) reported that chitosan and aloe vera-based coatings combined with thyme oil preserved the firmness of 'Hass' avocados. Wax coating can preserve more cell turgidity and give firmer fruit than the control because it limits moisture loss by building barriers between the fruit and the environment.

Moisture loss is linked to both mass loss and fruit softening (Aguirre-Joya *et al.*, 2017). Fruit softening involves solubilization of pectic substances; break down of starch to soluble sugars and loss of water from the peel (Mebratie *et al.*, 2015).

### **5.5.2 Total Soluble Solids (TSS) or % Brix.**

Total soluble solids (TSS) is a quality measure that indicates the ripeness or amount of sugar present in the juice of fruits (Bexiga *et al.*, 2017). The results showed that the TSS contents in

the Control, SB, and NO fruits increased rapidly during the first six days of storage, and then decreased until the end of storage. The rise of the TSS content of the fruits can be a result of the hydrolysis of starch during postharvest storage. According to Shahid & Abbasi (2011a), an increase in TSS can be attributed to ripening and hydrolysis of starch into sugars as well as the buildup of various solutes in cell vacuoles while the drop in TSS can be due to a delay in starch breakdown into sugars, as well as the conversion of polysaccharides into disaccharides and monosaccharides as a result of changes in metabolic activity. (Amulya, 2016) attributed the rise in TSS content during storage to higher respiration and transition of fruits toward ripening. (Pinzon *et al.*, 2020) discovered that, TSS of both coated and uncoated strawberries increased during storage, with uncoated fruit reaching a maximum of 9.5%, while coated strawberries reached maximums between 8.0% and 8.9%. However, the later slowed downwards trend of TSS during storage can be as a result of the rate of respiration or oxidation during storage and also the set in of senescence. Khaliq *et al.* (2019) attributed the decline in TSS during storage to the respiratory process leading to a reduction in carbohydrates and the breakdown of glycosides.

### 5.5.3 Titratable Acidity.

The primary components of TA are organic acids, which are often used as substrates for enzymatic respiration reactions (Hazrati, 2017). As a result, TA content is recognized as an essential indicator of fruit respiration rate and, it also indicates the ratio between sweetness and acidity (Xu *et al.*, 2018).

The study revealed that the TA content in the Control decreased throughout the storage period. TA content of BW and SB + BW increased during the first three days of storage and decreased gradually at sixth and the twelfth day of storage and then increased again at the fifteenth day of

storage. Throughout the storage period, there were significant differences between the Control and wax treatment ( $P < 0.05$ ). The rise in TA could be as a result of an increase in respiration of the fruit during storage. This agrees with Liu *et al.* (2009) report that increasing TA could be caused by increased respiration rate and creation of high levels of CO<sub>2</sub>, disrupting glycolytic enzyme systems and resulting in acid buildup. Hazarika *et al.* (2019) investigated the influence of edible coatings on quality attributes and shelf-life in strawberry fruits during storage. The authors observed that the titratable acidity of the fruits increased throughout storage and the fruits treated with wax emulsion (0.177%) recorded the significant highest titratable acidity at 16 days of storage followed by (0.176%) coconut oil. Khalid *et al.* (2021) discovered that when 'Kinnow' mandarin fruits were coated with carboxymethyl cellulose coating and stored at low temperature, the fruits' titratable acidity (TA) decreased significantly as storage days increased. However, the TA decrease was significantly higher in controls compared to CMC coated groups. Valero *et al.* (2013), attribute the decrease in TA during postharvest storage of plums to the use of organic acids as substrate for the respiratory metabolism in the fruit.

#### **5.5.4 Vitamin C Content**

The juice in fruits is usually enriched with vitamin C also known as ascorbic acid. This vitamin plays a vital role in the human body to enhance good health. According to Bisen *et al.* (2012) ascorbic acid is one of the powerful antioxidants and scavengers of the reactive oxygen species (ROS) produced in the body thus helping to save human from many serious diseases. It was observed in this study that as the storage period advances vitamin C content of the fruits decreased for all treatments. The declining trend in vitamin C content due to days of storage can be a result of the environmental condition of the storage area since high temperature in the storage area causes a reduction in vitamin C content. According to Maniwaru *et al.* (2015), exposure to light, oxygen,

and high temperatures result in the degradation of vitamin C in fruits. Sang (2020) discovered that overall, vitamin C content in passion fruits of treated samples and control samples gradually decrease with increasing storage time. Zahedi *et al.* (2019) attributed the rapid decrease of vitamin C content during storage and fruit ripening to ascorbinase (the enzyme that oxidizes and decomposes ascorbic acid) activity. Earlier report by Gupta & Jain (2014) on storage behavior of mango as affected by postharvest application of plant extracts and storage conditions indicated gradual decline in vitamin 'C' content of all the treatments over storage period. Untreated control fruits recorded a significantly higher rate of decrease in vitamin C as compared to treated fruits and the authors attributed the rapid decline in vitamin C content of the fruit to oxidation because of greater availability of oxygen.

### 5.5.5 pH

The present study revealed that there were significant changes in pH throughout the storage period. pH content of the Control, SB, NO, SB +NO, and NO+BW increased while BW, SB+BW SB + NO+BW decreased during the first six days of storage. At nine days of storage the Control, SB, NO, SB +NO, and NO+BW decreased in pH value while BW, SB+BW, and SB+NO+BW recorded a high value of pH. Shahid & Abbasi (2011a) investigated the effect of bee wax coatings on physiological changes in fruits of sweet orange. The authors concluded that the increase in pH could be due to the fast rate of metabolic activity, resulting in a decrease in acidity but an increase in pH, as well as the high TSS concentrations. The authors added that a decrease in pH could be caused by protein breakdown and carbohydrate fermentation. The oxidation of some food components, such as aldehyde and ketones, which produces corresponding acids, may cause a decline in pH.

#### 5.5.6 Shelf-Life.

Self-life of fresh produce refers to how long the produce can be safe for consumption. After fresh produce is detached from the parent plant they can only be considered fit for consumption as long as they are safe and still meet the consumer's preferred taste, texture, and appearance. In this study the Control fruits lasted for 9 days while waxed fruits irrespective of the waxing materials stored for more than 12 days. The best results was obtained by BW fruits. Osae (2017) attributed the shorter shelf-life of unwaxed tomato fruits to a higher respiration rate during storage, whereas waxed fruits had a longer shelf-life due to the waxing substance slowing respiration rate. Eshetu *et al.* (2019) studied the effect of beeswax and chitosan treatments on the quality and shelf-life of selected mango (*Mangifera indica L.*) cultivars. The authors discovered that fruits treated with 2% beeswax and chitosan had a greater shelf-life index value (30 days) than fruits treated with other treatments. Mandal *et al.* (2018) suggested that at room temperature wax coating can be an effective postharvest management practice to extend shelf- life while maintaining physico-chemical qualities of tomato cv. Samrudhi.

#### 5.5.7 Sensory Evaluation.

Based on the organoleptic evaluation performed on the yellow melon fruits, it was found that treated fruits were the most preferred. The treated were able to retain all sensory attributes compared to the Control fruits. Among the treated fruits BW treated fruit were the most preferred considering all the sensory attributes. Lamptey (2013) reported that consumers showed strong acceptability for neem palm wax treatment on watermelon than the Control treatment.

### 5.5.8 Pathogen Identified and Pathogenicity Studies

Postharvest diseases of horticulture crops are caused by a variety of pathogens. However, only *Lasiodiplodia theobromae* was identified to cause yellow melon rot in this study. In Ghana, the pathogen had been identified as the causal agent of diseases on cocoa, kola, and mango, and in Hawaii stem end rot of papaya (Saeed, 2012; Offei *et al.*, 2008; Nishijima, 1993). The fungus is also reported to cause rot in soursop fruit in Nigeria (Amusa *et al.*, 2003).

The pathogenic ability of the organism proved positive as it was able to cause decay and reduced the shelf- life when inoculated onto healthy fresh samples of the fruits causing postharvest losses. The symptoms that appeared on the diseased fruit made it both unmarketable and unwholesome for household use therefore, causing financial and economic losses to both farmers and traders.



## CHAPTER SIX

### 6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 SUMMARY

This study was set out to assess the influence of different local edible coatings on the physical, chemical, and organoleptic properties of canary yellow melon (*Cucumis melo var. inodorus*). The Afienya - Prampram District was selected for the field data.

The study specifically focused on the following key themes; The postharvest management practices along the yellow melon value in Afienya - Prampram District; The Effect of different waxing materials on the quality changes of yellow melon fruits; Consumer acceptability of coated yellow melon fruits; organisms identified after isolation and pathogenicity test.

The study was broadly carried out in two phases -a survey involving farmers and traders and a laboratory analysis. In the first phase, postharvest handling practices along the yellow melon value chain in Afienya - Prampram District of Ghana was assessed. One hundred open-ended and close-ended questionnaires were administered to farmers and traders of yellow melon. For the second phase, the influence of different local edible coatings on the physical, chemical, and organoleptic properties of canary yellow melon were assessed. Eight (8) treatments were laid out in Completely Randomized Design (CRD) with three replications of 18 fruits per treatment. Seven waxing materials (Shea Butter, Neem Oil, Beeswax, Shea Butter + Beeswax, Shea Butter + Neem Oil, Neem Oil + Beeswax, Shea Butter + Beeswax + Neem Oil) were used for coating the yellow melon fruits. Treated fruits plus control fruits were kept at ambient condition (29.3–31.3 °C, 69.0–72.0% RH) till 21 days and assessed for various quality indices including weight loss, firmness, pH, total soluble solids (TSS), total titratable acids (TTA), vitamin C and shelf-life.

## 6.2.0 FINDINGS

The following were the findings of this study:

### 6.2.1 Postharvest management practices along the yellow melon value in Afienya - Prampram District

From the study, the value chain of yellow melon fruits starts from pre-harvest and ends with the consumer. Farmers, traders (wholesalers, retailers, and transporters), and consumers are the main players along the value chain. Most of the farmers use their seeds for subsequent planting after obtaining their first seeds from friends or certified dealers. Before planting or harvesting the farmer arranges for buyers. The crop is cultivated twice or thrice a year because of the availability of irrigation facility on site. The fruits are harvested manually when they attain yellow ripe. Most farmers choose to harvest their fruits in the morning or evening because of the convenience of working under cool temperatures. Sorting, packing, and sale of the fruit is usually carried out at the farm gate. The majority of the farmers had assessed to extension services but the services rendered did not include postharvest technology. Postharvest losses are recorded throughout the value chain. Some of the losses recorded are mechanical, physiological, and biological (rot and pest attack). Lack of appropriate vehicles for transporting fruit, lack of storage facilities, and technology are among the challenges the handlers face. Respondents did not have any knowledge about waxing and did not know of any modern storage technology but were however willing to adopt modern storage technology that will extend the shelf life of the fruits.

### 6.2.2 The Effect of Different Waxing Materials on the Quality Changes of Yellow Melon Fruits

Results from the experiment indicated that all coated treatments were able to preserve the quality indices measured thereby delaying decay and extending the shelf life of the fruit. Maximum shelf life was observed in fruits coated with BW (18 days) with the lowest shelf life of only 9 days recorded in control (uncoated fruits). BW only, SB only, and BW and its combination coated fruits

were found good enough to ensure firmness and also reduce percentage weight loss. BW only and SB + NO helped in reducing Vitamin C loss.

### **6.2.3 Consumer Acceptability of Coated Yellow Melon Fruits**

Generally, the panelist accepted the treated fruits and was willing to purchase fruits treated with the local edible coatings. The treatments were able to improve glossiness and attractiveness. Fruits treated with BW and its combinations were able to retain texture, rind, and pulp colour.

### **6.2.4 Organisms Identified after Isolation**

*Lasiodiplodia theobromae* was the pathogen identified to cause yellow melon rot in the study area.

### **6.2.5 Pathogenicity Test**

All isolates of *Lasiodiplodia theobromae* used for the inoculation studies were able to induce the rot disease symptoms on the inoculated fruits. The diseased fruits showed signs of decay at both the internal and external parts. There was a general colour change on both sides with water-soak tissue found at the internal part. The oozing water from the decayed fruit gave off a bad smell.

## **6.3 CONCLUSIONS**

The following conclusions were drawn from this study:

Results obtained from phase I of the study showed that farmers ensured that there were available markets before the fruits were planted and even harvested. The majority of the farmers had access to extension services but the services rendered did not include postharvest technology. Postharvest losses were recorded throughout the value chain of the fruit. Postharvest losses were recorded throughout the value chain of the fruit. Some of the losses recorded were mechanical, physiological, and biological (rot and pest attack). Notably, 66% mechanical loss at harvest was reported by the respondents. At the sale point, 82% of traders recorded losses and the rate of spoilage was up to 98%. The total economic loss incurred by the farmers was estimated at GH¢ 17, 500 out of an expected income of GH¢ 80,000. While that of the traders was GH¢ 4,300 out

of an expected income of GH¢ 15,000. Lack of appropriate vehicles for transportation of fruits, lack of storage facilities and postharvest technology were among the challenges the handlers of the fruit faced. Respondents did not have any knowledge about waxing and did not know of any modern storage technology but were willing to adopt storage technologies.

Results from the laboratory analysis, indicated that all coated treatments were able to preserve the fruits quality indices during the storage period. Longer shelf-life was observed in fruits coated with BW (18 days) while the shortest shelf-life of nine days was recorded for the control (uncoated fruits). Fruits coated with BW, SB and BW and its combination maintain fruit firmness and also reduce percentage weight loss. Fruits coated with BW and SB + NO recorded lower Vitamin C loss. Sensory evaluation revealed the overall acceptability of waxed fruits and consumers' willingness to purchase waxed fruits. BW can therefore be used to prolong the shelf-life, improve glossiness and attractiveness, ensure firmness and also reduce weight loss of yellow melon fruits.

Regarding the pathogenicity of organisms associated with postharvest rot of melon fruits, the results showed that the pathogen that causes yellow melon rot is *Lasiodiplodia theobromae*. The pathogenic ability of the organism proved positive as it was able to cause decay and reduced the shelf-life when inoculated onto healthy fresh samples of the fruits causing postharvest losses. The symptoms that appeared on the diseased fruit made it both unmarketable and unwholesome for household use therefore, causing financial and economic losses to both farmers and traders.

#### **6.4 RECOMMENDATIONS**

The following recommendations can be drawn from this study;

- a) Agreement between farmers and buyers before planting or harvesting should be documented to avoid future disappointment that will lead to losses.
- b) Along the value chain (harvesting, sorting, packaging, transportation, and storage) general care should be considered during fruit handling.
- c) Best results can be achieved when baskets are cushioned with soft material to reduce impact during handling and transportation, throwing fruits into baskets and overloaded should be avoided to reduce bruises, which result in losses
- d) The presence of specialized temperature control vehicles and storage facilities can significantly reduce post-harvest losses.
- e) The use of black polythene sheets, nylon sacks, and tarpaulin for covering fruits during transportation and storage should be avoided to prevent the buildup of heat that will accelerate postharvest losses.
- f) Extension workers should include postharvest services to farmers and other food handlers to preserve the quality of the fruits and also reduce losses.
- g) Researchers should disseminate new postharvest findings to extension workers to enable them to carry out their services efficiently.
- h) It is therefore recommended that BW and its combination should be used to treat yellow melon fruits to prolong the shelf life and also preserve the physical, chemical, and organoleptic properties.



## REFERENCES

Abbott, J. A. (1999). Quality measurement of fruits and vegetables. *Postharvest biology and technology*, 15(3), 207-225.

Abdallah, E. H., & Abu-Goukh, A. A. (2010). Effect of gibberellic acid and waxing on quality and storability of lime fruits. *University of Khartoum Journal of Agricultural Sciences*, 18(3), 349-362.

Abdelfattah, Ahmed, et al. "Effect of washing, waxing and low-temperature storage on the postharvest microbiome of apple." *Microorganisms* 8.6 (2020): 944.

Abdolahi, A., Hassani, A., Ghosta, Y., Bernousi, I., & Meshkatalsadat, M. (2010). Study on the potential use of essential oils for decay control and quality preservation of Tabarzeh table grape. *Journal of Plant Protection Research*, 50(1).

Abdullah, F. A., & Samah, B. A. (2013). Factors impinging farmers' use of agriculture technology. *Asian Social Science*, 9(3), 120.

Abdullah, Q., Mahmoud, A., & Al-Harethi, A. (2016). Isolation and identification of fungal post-harvest rot of some fruits in Yemen. *PSM Microbiol*, 1(1), 36-44.

Abeles, F. B., Morgan, P. W., & Saltveit Jr, M. E. (2012). *Ethylene in plant biology*. Academic press.

- Abu-Goukh, A. A., & Shattir, A. E. (2012). Effect of maleic hydrazide and waxing on quality and shelf life of papaya (*Carica papaya* L.) fruits. *University of Khartoum Journal of Agricultural Sciences*, 20(1), 62-76.
- Abu-Shama, H. S., Abou-Zaid, F. O. F., & El-Sayed, E. Z. (2020). Effect of using edible coatings on fruit quality of Barhi date cultivar. *Scientia Horticulturae*, 265, 109262.
- AOAC, 1990. *Official Method of Analysis; Association of Analytical Chemists*, 15<sup>th</sup> edition. Arlington, Virginia, USA
- Adamu, Y., Jongur, A. A. U., & Onu, J. I. (2017). *Differentials in Returns of Watermelon (Citrullus lanatus) and Sweet Melon (Cucumis melon) Production among Farmers in Gombe and Bauchi States, Nigeria.*
- Adhikari, B., & Aarati, G. C. (2021). Post-harvest practices of horticultural crops in Nepal: Issues and management. *Archives of Agriculture and Environmental Science*, 6(2), 227-233.
- Agricultural Marketing Resource Center. 2018. Melons. 30 October 2020. <https://www.agmrc.org/commodities-products/vegetables/melons>. (Accessed 11/1/2021)
- Agrios, G.N. (1988). *Plant pathology*. Academic press, New York. 11:274-280.
- Aguirre-Joya, J. A., Ventura-Sobrevilla, J., Martínez-Vazquez, G., Ruelas-Chacón, X., Rojas, R., Rodríguez-Herrera, R., & Aguilar, C. N. (2017). Effects of a natural bioactive coating on the quality and shelf life prolongation at different storage conditions of

- avocado (*Persea Americana* Mill.) cv. Hass. *Food Packaging and Shelf Life*, 14, 102-107.
- Ahmad, M. S., & Siddiqui, M. W. (2015). Factors affecting postharvest quality of fresh fruits. In *Postharvest quality assurance of fruits* (pp. 7-32). Springer, Cham.
- Ahmad, M. S., & Siddiqui, M. W. (2015). *Postharvest quality assurance of fruits*. Cham: Springer.
- Ahmadi, E., Ghassemzadeh, H. R., Sadeghi, M., Moghaddam, M., & Neshat, S. Z. (2010). The effect of impact and fruit properties on the bruising of peach. *Journal of Food Engineering*, 97(1), 110-117.
- Ahmed, A., Ali, S. W., Imran, A., Afzaal, M., Arshad, M. S., Nadeem, M., & Ikram, A. (2020). Formulation of date pit oil-based edible wax coating for extending the storage stability of guava fruit. *Journal of Food Processing and Preservation*, 44(2), e14336.
- Ahvenainen, R. (Ed.). (2003). *Novel food packaging techniques*. Elsevier.
- Ait-Oubahou, A., Brecht, J. K., & Yahia, E. M. (2019). Packing operations. In *Postharvest Technology of Perishable Horticultural Commodities* (pp. 311-351). Woodhead Publishing.
- Aji, T. G., Susanto, S., Sukma, D., & Ardie, S. W. (2017). Improvement of shelf life and sensory quality of pummelos by fruit waxing and wrapping. *Journal of Tropical Crop Science*, 4(1).

- Ajuru, M. G., & Okoli, B. E. (2013). The morphological characterization of the melon species in the family Cucurbitaceae Juss., and their utilization in Nigeria. *International Journal of Modern Botany*, 3(2), 15-19.
- Ajuru, M., & Nmom, F. (2017). A review on the economic uses of species of Cucurbitaceae and their sustainability in Nigeria. *American Journal of plant biology*, 2(1), 17-24.
- Al Fadil, M. B., Abu-Goukh, A. B. A., & Mustafa, M. A. (2015). Effect of harvesting time on quality and shelf-life of three 'Galia' cultivars. *Gezira Journal of Agricultural Science*, 13(1).
- Aldoshin, N., Mamatov, F., Ismailov, I., & Ergashov, G. (2020, May). Development of combined tillage tool for melon cultivation. In *19th international scientific conference engineering for rural development Proceedings, Jelgava* (Vol. 20, No. 22.05).
- Al-Harrasi, A., Rehman, N. U., Hussain, J., Khan, A. L., Al-Rawahi, A., Gilani, S. A., ... & Ali, L. (2014). Nutritional assessment and antioxidant analysis of 22 date palm (*Phoenix dactylifera*) varieties growing in Sultanate of Oman. *Asian Pacific journal of tropical medicine*, 7, S591-S598.
- Ali, A., Maqbool, M., Ramachandran, S., & Alderson, P. G. (2010). Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. *Postharvest biology and technology*, 58(1), 42-47.
- Ali, J., Pandey, S., Singh, V., & Joshi, P. (2016). Effect of coating of aloe vera gelon shelf life of grapes. *Current Research in Nutrition and Food Science Journal*, 4(1), 58-68.

- Amin, M., Ullah, S., Rehman, S., Ullah, Z., & Amir, M. (2014). Comparison of different types of water melon for their important nutrients. *Journal of Biology, Agriculture and Healthcare*, 4(14), 59-66.
- Amulya, P. R., Sudheer, K. P., Rifna, E. J., Sreesha, K. R., & Nusaiba, C. (2016). Effect of edible wax coating and map on the quality of mango during storage. *International Journal of Agricultural Science and Research (IJASR)*, 6(4), 13-18.
- Amusa, N. A., Ashaye, O. A., Oladapo, M. O., & Kafaru, O. O. (2003). Pre-harvest deterioration of Sour sop (*Annona muricata*) at Ibadan Southwestern Nigeria and its effect on nutrient composition. *African Journal of Biotechnology*, 2(1), 23-25.
- Andrade, R., Skurtys, O., & Osorio, F. (2013). Drop impact behavior on food using spray coating: Fundamentals and applications. *Food research international*, 54(1), 397-405.
- Anjum, M. A., Akram, H., Zaidi, M., & Ali, S. (2020). Effect of gum arabic and Aloe vera gel based edible coatings in combination with plant extracts on postharvest quality and storability of 'Gola' guava fruits. *Scientia Horticulturae*, 271, 109506.
- 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.
- Arah, I. K., Amaglo, H., Kumah, E. K., & Ofori, H. (2015). Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: a mini review. *International Journal of Agronomy*, 2015.
- Ars, R. S. (2014). *A textbook of Glaustas Olericulture*. New vishal publications.

- Ashraf, M. Y., Yaqub, M., Akhtar, J., Khan, M. A., Ali-Khan, M., & Ebert, G. (2012). Control of excessive fruit drop and improvement in yield and juice quality of Kinnow (*Citrus deliciosa* x *Citrus nobilis*) through nutrient management. *Pak. J. Bot*, *44*, 259-265.
- Atanda S. A., Pessu P. O., Agoda S., Isong I. U. and Ikotun I. (2011). The concepts and problems of post-harvest food losses in perishable crops. *African Journal of Food Science*, *5* (11): 603-613
- Azene, M., Workneh, T. S., & Woldetsadik, K. (2014). Effect of packaging materials and storage environment on postharvest quality of papaya fruit. *Journal of food science and technology*, *51*(6), 1041-1055.
- Azikiwe, A. I., & Monde, N. O. A. and Sunday, and OA 2013. "Quality of Extension Services: A Case Study of Farmers in Amathole." *Journal of Agricultural Science*, *5*(2).
- Babarinsa, F. A., Ogundele, R. B., Babarinsa, O. A., & Omodara, M. A. (2018). Evaluation of plastic crate as replacement for raffia basket to prevent in-transit damage of packaged tomatoes. *Journal of Postharvest Technology*, *6*(3), 70-79.
- Babushkina, E. A., Belokopytova, L. V., Grachev, A. M., Meko, D. M., & Vaganov, E. A. (2017). Variation of the hydrological regime of Bele-Shira closed basin in Southern Siberia and its reflection in the radial growth of *Larix sibirica*. *Regional Environmental Change*, *17*(6), 1725-1737.
- Bachmann, J., & Earles, R. (2000). *Postharvest handling of fruits and vegetables* (pp. 1-19). Ozark Mountains, University of Arkansas, Fayetteville, NC, USA: ATTRA.

- Banjaw, T. D. (2017). Review of post-harvest loss of horticultural crops in Ethiopia, its causes and mitigation strategies. *J. Plant Sci. Agric. Res*, 2(1), 006.
- Banjaw, T. D. (2017). Review of post-harvest loss of horticultural crops in Ethiopia, its causes and mitigation strategies. *J. Plant Sci. Agric. Res*, 2(1), 006.
- Barman, K., Asrey, R., & Pal, R. K. (2011). Putrescine and carnauba wax pretreatments alleviate chilling injury, enhance shelf life and preserve pomegranate fruit quality during cold storage. *Scientia Horticulturae*, 130(4), 795-800.
- Barnett, H. L., & Hunter, B. B. (1972). Illustrated genera of imperfect fungi. *Illustrated genera of imperfect fungi*, (3rd ed).
- Basediya A.L., Samuel D.V.K., Beera V. (2013): Evaporative cooling system for storage of fruits and vegetables – a review. *Journal of Food Science and Technology*, 50: 429–442. <https://doi.org/10.1007/s13197-011-0311-6>
- Basu, S., Shivhare, U. S., Singh, T. V., & Beniwal, V. S. (2011). Rheological, textural and spectral characteristics of sorbitol substituted mango jam. *Journal of Food Engineering*, 105(3), 503-512.
- Ben-Yehoshua, S., Rodov, V., Fishman, S., & Peretz, J. (1996, August). Modified-atmosphere packaging of fruits and vegetables: reducing condensation of water in bell peppers and mangoes. In *International Postharvest Science Conference Postharvest 96* 464 (pp. 387-392).

- Bernard, A., & Joubès, J. (2013). Arabidopsis cuticular waxes: advances in synthesis, export and regulation. *Progress in lipid research*, 52(1), 110-129.
- Beune, R. (2018). *Income intervention quick scan: post-harvest loss prevention measures: Farmer Income Lab Intervention Quick Scan* (No. 18-033). Wageningen Centre for Development Innovation.
- Bexiga, F., Rodrigues, D., Guerra, R., Brázio, A., Balegas, T., Cavaco, A. M., & de Oliveira, J. V. (2017). A TSS classification study of ‘Rocha’ pear (*Pyrus communis* L.) based on non-invasive visible/near infra-red reflectance spectra. *Postharvest Biology and Technology*, 132, 23-30.
- Bhardwaj, R. L., & Pandey, S. (2011). Juice blends—a way of utilization of under-utilized fruits, vegetables, and spices: a review. *Critical reviews in food science and nutrition*, 51(6), 563-570.
- Bill, M., Sivakumar, D., Korsten, L., & Thompson, A. K. (2014). The efficacy of combined application of edible coatings and thyme oil in inducing resistance components in avocado (*Persea Americana* Mill.) against anthracnose during post-harvest storage. *Crop Protection*, 64, 159-167.
- Bisen, A., Pandey, S. K., & Patel, N. (2012). Effect of skin coatings on prolonging shelf life of kagzi lime fruits (*Citrus aurantifolia* Swingle). *Journal of food science and technology*, 49(6), 753-759.
- Bourne, M. (1977). Postharvest food losses—the neglected dimension in increasing the world food supply.

- Bovi, G. G., Rux, G., Caleb, O. J., Herppich, W. B., Linke, M., Rauh, C., & Mahajan, P. V. (2018). Measurement and modelling of transpiration losses in packaged and unpackaged strawberries. *Biosystems Engineering*, *174*, 1-9.
- Brizzolara, S., Manganaris, G. A., Fotopoulos, V., Watkins, C. B., & Tonutti, P. (2020). Primary metabolism in fresh fruits during storage. *Frontiers in plant science*, *11*, 80.
- Buchholz, F., Kostić, T., Sessitsch, A., & Mitter, B. (2018). The potential of plant microbiota in reducing postharvest food loss. *Microbial biotechnology*, *11*(6), 971-975.
- Buchholz, F., Kostić, T., Sessitsch, A., & Mitter, B. (2018). The potential of plant microbiota in reducing postharvest food loss. *Microbial biotechnology*, *11*(6), 971-975.
- Burger, Y., Sa'ar, U., Paris, H. S., Lewinsohn, E., Katzir, N., Tadmor, Y., & Schaffer, A. A. (2006). Genetic variability for valuable fruit quality traits in *Cucumis melo*. *Israel Journal of Plant Sciences*, *54*(3), 233-242.
- Caleb, O. J., Mahajan, P. V., Al-Said, F. A., & Opara, U. L. (2013). Transpiration rate and quality of pomegranate arils as affected by storage conditions. *CyTA-Journal of Food*, *11*(3), 199-207.
- Carr, A. C., & Maggini, S. (2017). Vitamin C and immune function. *Nutrients*, *9*(11), 1–25. <https://doi.org/10.3390/nu9111211>
- Chebrolu, K. K., Jayaprakasha, G. K., Yoo, K. S., Jifon, J. L., & Patil, B. S. (2012). An improved sample preparation method for quantification of ascorbic acid and dehydroascorbic acid by HPLC. *LWT*, *47*(2), 443-449.

- Chen, G., Chen, J., Feng, Z., Mao, X., & Guo, D. (2015). Physiological responses and quality attributes of Jiashi muskmelon (*Cucurbitaceae*, *Cucumis melo* L.) following postharvest hydrogen peroxide treatment during storage. *Eur. J. Hortic. Sci*, 80, 288-295.
- Chen, H., Sun, Z., & Yang, H. (2019). Effect of carnauba wax-based coating containing glycerol monolaurate on the quality maintenance and shelf-life of Indian jujube (*Zizyphus mauritiana* Lamk.) fruit during storage. *Scientia horticulturae*, 244, 157-164.
- Chen, L., & Opara, U. L. (2013a). Texture measurement approaches in fresh and processed foods—A review. *Food research international*, 51(2), 823-835.
- Chen, L., & Opara, U. L. (2013b). Approaches to analysis and modeling texture in fresh and processed foods—A review. *Journal of food Engineering*, 119(3), 497-507.
- Cheour F, Willemot C, Arul J, Makhlof DY (1991). Postharvest response of two strawberry cultivars to foliar application of  $\text{CaCl}_2$ . Alexandria, VA, ETATS-UNIS: American Society for Horticultural Science: Hort. Sci., pp. 1186-1188.
- Contreras-Oliva, A., Rojas-Argudo, C., & Pérez-Gago, M. B. (2011). Effect of solid content and composition of hydroxypropyl methylcellulose–lipid edible coatings on physicochemical, sensory and nutritional quality of ‘Valencia’ oranges. *International journal of food science & technology*, 46(11), 2437-2445.
- Contreras-Oliva, A., Rojas-Argudo, C., & Pérez-Gago, M. B. (2012). Effect of solid content and composition of hydroxypropyl methylcellulose–lipid edible coatings on physico-

- chemical and nutritional quality of ‘Oronules’ mandarins. *Journal of the Science of Food and Agriculture*, 92(4), 794-802.
- Damiani, O. (2003). Diversificação agrícola e redução de pobreza: A introdução no nordeste brasileiro de produtos agrícolas não-tradicionais de alto valor e seus efeitos sobre pequenos produtores e trabalhadores rurais assalariados. *Revista Econômica do Nordeste*, 34(1), 42-84.
- Dávila-aviña, J. E. D. J., Villa-rodríguez, J., Cruz-valenzuela, R., Rodríguez-armenta, M., Espino-díaz, M., Ayala-zavala, J. F., Olivas-orozco, G. I., Heredia, B., & González-aguilar, G. (2011). *Effect of Edible Coatings, Storage Time and Maturity Stage on Overall Quality of Tomato Fruits*. 6(1), 162–171.
- de Macêdo, R. V. B. T., Sarmiento, R. A., Pereira, P. S., Lima, C. H. O., de Deus, T. L. L. B., Ribeiro, A. V., & Picanço, M. C. (2019). Sampling plan for *Bemisia tabaci* (Hemiptera: Aleyrodidae) in melon crops. *Florida Entomologist*, 102(1), 16-23.
- Dev, S. M. (2012). Small Farmers in India: Challenges and Opportunities. Indira Gandhi Institute of Development Research. *Mumbai June*. <http://www.igidr.ac.in/pdf/publication/WP-2012-014.pdf>.
- Dhall, R.K. (2016), “Application of Coatings and Films in Fruits and Vegetables Chapter”, in Tiwari, A., Galanis, A. and Soucek, M.D. (Eds), *Biobased and Environmental Benign Coatings Biobased and Environmental Benign Coatings*, Wiley, pp. 87-119.
- Dhiman, K., Gupta, A., Sharma, D. K., Gill, N. S., & Goyal, A. (2012). A review on the medicinally important plants of the family Cucurbitaceae. *Asian Journal of Clinical Nutrition*, 4(1), 16-26.

- Dias, C., L Amaro, A., C Salvador, Â., Silvestre, A. J., Rocha, S. M., Isidoro, N., & Pintado, M. (2020). Strategies to preserve postharvest quality of horticultural crops and superficial scald control: From diphenylamine antioxidant usage to more recent approaches. *Antioxidants*, 9(4), 356.
- Dong, Feng, and Xiaolin Wang. "Guar gum and ginseng extract coatings maintain the quality of sweet cherry." *LWT* 89 (2018): 117-122.
- Dong, S., & Beckles, D. M. (2019). Dynamic changes in the starch-sugar interconversion within plant source and sink tissues promote a better abiotic stress response. *Journal of Plant Physiology*, 234–235(May 2018), 80–93.  
<https://doi.org/10.1016/j.jplph.2019.01.007>
- Du Plooy, W., Regnier, T., & Combrinck, S. (2009). Essential oil amended coatings as alternatives to synthetic fungicides in citrus postharvest management. *Postharvest Biology and Technology*, 53(3), 117-122.
- Duan, X., OuYang, Q., & Tao, N. (2018). Effect of applying cinnamaldehyde incorporated in wax on green mould decay in citrus fruits. *Journal of the Science of Food and Agriculture*, 98(2), 527-533.
- Dukare, A. S., Paul, S., Nambi, V. E., Gupta, R. K., Singh, R., Sharma, K., & Vishwakarma, R. K. (2019). Exploitation of microbial antagonists for the control of postharvest diseases of fruits: a review. *Critical reviews in food science and nutrition*, 59(9), 1498-1513.

- Ebrahimi, F., & Rastegar, S. (2020). Preservation of mango fruit with guar-based edible coatings enriched with *Spirulina platensis* and Aloe vera extract during storage at ambient temperature. *Scientia Horticulturae*, 265, 109258.
- Egoumenides, L., Gauthier, A., Barial, S., Saby, M., Orechenkoff, C., Simoneau, G., & Carillon, J. (2018). A specific melon concentrate exhibits photoprotective effects from antioxidant activity in healthy adults. *Nutrients*, 10(4), 437.
- Elik, A., Yanik, D. K., Istanbulu, Y., Guzelsoy, N. A., Yavuz, A., & Gogus, F. (2019). Strategies to reduce post-harvest losses for fruits and vegetables. *Strategies*, 5(3), 29-39.
- Endl, J., Achigan-Dako, E. G., Pandey, A. K., Monforte, A. J., Pico, B., & Schaefer, H. (2018). Repeated domestication of melon (*Cucumis melo*) in Africa and Asia and a new close relative from India. *American Journal of Botany*, 105(10), 1662-1671.
- Eshetu, A., Ibrahim, A. M., Forsido, S. F., & Kuyu, C. G. (2019). Effect of beeswax and chitosan treatments on quality and shelf life of selected mango (*Mangifera indica* L.) cultivars. *Heliyon*, 5(1), e01116.
- Eshghi, S., Hashemi, M., Mohammadi, A., Badii, F., Mohammadhoseini, Z., & Ahmadi, K. (2014). Effect of nanochitosan-based coating with and without copper loaded on physicochemical and bioactive components of fresh strawberry fruit (*Fragaria x ananassa* Duchesne) during storage. *Food and bioprocess technology*, 7(8), 2397-2409.
- Esteras, C., Rambla, J. L., Sánchez, G., Granell, A., & Picó, M. B. (2020). Melon genetic resources characterization for rind volatile profile. *Agronomy*, 10(10), 1512.

- Ezzat, S. M., Raslan, M., Salama, M. M., Menze, E. T., & El Hawary, S. S. (2019). In vivo anti-inflammatory activity and UPLC-MS/MS profiling of the peels and pulps of *Cucumis melo* var. *cantalupensis* and *Cucumis melo* var. *reticulatus*. *Journal of ethnopharmacology*, 237, 245-254.
- Faqeerzada, M. A., Rahman, A., Joshi, R., Park, E., & Cho, B. K. (2018). Postharvest technologies for fruits and vegetables in South Asian countries: a review. *Korean Journal of Agricultural Science*, 45(3), 325-353.
- Fatima, S., Baig, M., Ahire, P. P., & Kadam, V. B. (2012). Studies on management of *Aspergillus* rot of amla. *Int. J. Sci*, 2.
- Fenech, M., Amaya, I., Valpuesta, V., & Botella, M. A. (2019). Vitamin C content in fruits: Biosynthesis and regulation. *Frontiers in Plant Science*, 9(January), 1–21. <https://doi.org/10.3389/fpls.2018.02006>
- Ferreira, M. D., Brecht, J. K., Sargent, S. A., & Aracena, J. J. (1994). Physiological responses of strawberry to film wrapping and precooling methods. In *Proceedings of the Florida State Horticultural Society* (Vol. 107, pp. 265-268).
- Freitas, J., Sobrinho, R. B., & de ANDRADE, A. P. S. (2009). Integrated melon production in the Mossoró-Açu and Baixo Jaguaribe clusters: diagnosis of compliance and non-compliance with system requirements.
- Fukuma, Y., Yamane, A., Itoh, T., Tsukamasa, Y., & Ando, M. (2012). Application of supercooling to long-term storage of fish meat. *Fisheries science*, 78(2), 451-461.

- Fundo, J. F., Miller, F. A., Garcia, E., Santos, J. R., Silva, C. L., & Brandão, T. R. (2018). Physicochemical characteristics, bioactive compounds and antioxidant activity in juice, pulp, peel and seeds of Cantaloupe melon. *Journal of Food Measurement and Characterization*, 12(1), 292-300.
- Gall, M. D., Borg, W. R., & Gall, J. P. (1996). Educational research: An introduction. New York: Longman.
- Ganiari, S., Choulitoudi, E., & Oreopoulou, V. (2017). Edible and active films and coatings as carriers of natural antioxidants for lipid food. *Trends in Food Science & Technology*, 68, 70-82.
- General News (16th November, 2017). Six Billion Dollars worth food goes waste in Ghana. [www.adomonline.com](http://www.adomonline.com) (Accessed 19/7/2021)
- Ghana News Agency, (9th November, 2017). *Post-harvest Losses Cost 700, 000 Dollars Annually*. (Accessed 19/7/2021)
- Ghasemnezhad, M., Shiri, M. A., & Sanavi, M. (2010). Effect of chitosan coatings on some quality indices of apricot (*Prunus armeniaca* L.) during cold storage. *Caspian journal of environmental sciences*, 8(1), 25-33.
- Gil, M. I., Selma, M. V., Suslow, T., Jacxsens, L., Uyttendaele, M., & Allende, A. (2015). Pre- and postharvest preventive measures and intervention strategies to control microbial food safety hazards of fresh leafy vegetables. *Critical reviews in food science and nutrition*, 55(4), 453-468.

- Gilbert, C. L., Christiaensen, L., & Kaminski, J. (2017). Food price seasonality in Africa: Measurement and extent. *Food policy*, 67, 119-132.
- Guerreiro, A. C., Gago, C. M., Faleiro, M. L., Miguel, M. G., & Antunes, M. D. (2015). The effect of alginate-based edible coatings enriched with essential oils constituents on *Arbutus unedo* L. fresh fruit storage. *Postharvest Biology and Technology*, 100, 226-233.
- Guillén, F., Díaz-Mula, H. M., Zapata, P. J., Valero, D., Serrano, M., Castillo, S., & Martínez-Romero, D. (2013). Aloe arborescens and Aloe vera gels as coatings in delaying postharvest ripening in peach and plum fruit. *Postharvest biology and technology*, 83, 54-57.
- Guimaraes, A., Abrunhosa, L., Pastrana, L. M., & Cerqueira, M. A. (2018). Edible films and coatings as carriers of living microorganisms: A new strategy towards biopreservation and healthier foods. *Comprehensive Reviews in Food Science and Food Safety*, 17(3), 594-614.
- Gupta, N., & Jain, S. K. (2014). Storage behavior of mango as affected by post harvest application of plant extracts and storage conditions. *Journal of food science and technology*, 51(10), 2499-2507.
- Halder, P., & Pati, S. (2011). A need for paradigm shift to improve supply chain management of fruits & vegetables in India. *Asian Journal of Agriculture and Rural Development*, 1(393-2016-23908), 1-20.

Hazarika, T. K., Lalrinfeli, L., Lalchhanmawia, J. O. N. A. T. H. A. N., & Mandal, D. E. B. A.

S. H. I. S. (2019). Alteration of quality attributes and shelf-life in strawberry (*Fragaria× ananassa*) fruits during storage as influenced by edible coatings. *Indian Journal of Agricultural Sciences*, 89(1), 28-34.

Hazrati, S., Beyraghdar Kashkooli, A., Habibzadeh, F., Tahmasebi-Sarvestani, Z., & Sadeghi,

A. R. (2017). Evaluation of Aloe vera gel as an alternative edible coating for peach fruits during cold storage period. *Gesunde Pflanzen*, 69(3), 131-137.

Henan, I., Tlili, I., R'him, T., Ali, A. B., & Jebari, H. (2016). Carotenoid content and antioxidant activity of local varieties of muskmelon (*Cucumis melo* L.) grown in Tunisia. *Journal of New Sciences*, 29.

Hengsdijk, H., & De Boer, W. J. (2017). Post-harvest management and post-harvest losses of cereals in Ethiopia. *Food Security*, 9(5), 945-958.

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *The Journal of Agricultural Science*, 149(S1), 37-45.

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *The Journal of Agricultural Science*, 149(S1), 37-45.

Hu, H., Li, X., Dong, C., & Chen, W. (2012). Effects of wax treatment on the physiology and cellular structure of harvested pineapple during cold storage. *Journal of agricultural and food chemistry*, 60(26), 6613-6619.

- Hu, H., Li, X., Dong, C., & Chen, W. (2012). Effects of wax treatment on the physiology and cellular structure of harvested pineapple during cold storage. *Journal of agricultural and food chemistry*, 60(26), 6613-6619.
- Hurst, W. C. (2010). Harvest, Handling and Sanitation Commercial Tomato Production. Handbook B 1312. CAES Publications. University of Georgia.
- Hurst, W. C., Tybor, P. T., Reynolds, A. E., & Schuler, G. A. (2010). Quality control: a model program for the food industry.
- Ilyas, S. M. (2010). Best practices for efficient postharvest management of fruits and vegetables for higher value addition and profitability. In *Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables Proceedings of 2010 AARDO Workshop*. 農業試験所.
- ITIS, (2017). Integrated taxonomic information system. Integrated taxonomic information system report.  
[https://www.itis.gov/servlet/SingleRpt/SingleRpt?search\\_topic=TSN&search\\_value=22362#null](https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=22362#null) Google Scholar
- Isaac, K. A., Harrison, A., Ernest, K. K., & Hayford, O. (2015). Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes. *International Journal of Agronomy*, 20(15-16), 2015.
- Ishaq, S., Rathore, H. A., Masud, T., & Ali, S. (2009). Influence of postharvest calcium chloride application, ethylene absorbent and modified atmosphere on quality characteristics and shelf life of apricot (*Prunus armeniaca* L.) fruit during storage. *Pak. J. Nutr*, 8(6), 861-865.

- Ismail, M., Mariod, A., Bagalkotkar, G., & Ling, H. S. (2010). Fatty acid composition and antioxidant activity of oils from two cultivars of Cantaloupe extracted by supercritical fluid extraction. *Grasas y Aceites*, 61(1), 37-44.
- Jaeger, S. R., Antunez, L., Ares, G., Johnston, J. W., Hall, M., & Harker, F. R. (2016). Consumers' visual attention to fruit defects and disorders: A case study with apple images. *Postharvest Biology and Technology*, 116, 36-44.
- Jayasooriya, A. P., Sakono, M., Yukizaki, C., Kawano, M., Yamamoto, K., & Fukuda, N. (2000). Effects of Momordica charantia powder on serum glucose levels and various lipid parameters in rats fed with cholesterol-free and cholesterol-enriched diets. *Journal of ethnopharmacology*, 72(1-2), 331-336.
- Jo, W. S., Song, H. Y., Song, N. B., Lee, J. H., Min, S. C., & Song, K. B. (2014). Quality and microbial safety of 'Fuji' apples coated with carnauba-shellac wax containing lemongrass oil. *LWT-Food Science and Technology*, 55(2), 490-497.
- John, K. J., Scariah, S., Nissar, V. A., Latha, M., Gopalakrishnan, S., Yadav, S. R., & Bhat, K. V. (2013). On the occurrence, distribution, taxonomy and genepool relationship of Cucumis callosus (Rottler) Cogn., the wild progenitor of Cucumis melo L. from India. *Genetic resources and crop evolution*, 60(3), 1037-1046.
- Kader, A. A. (1997, August). Fruit maturity, ripening, and quality relationships. In *International Symposium Effect of Pre- & Postharvest factors in Fruit Storage* 485 (pp. 203-208).
- Kader, A. A. (2013). Postharvest technology of horticultural crops-An overview from farm to fork. *Ethiopian Journal of Applied Science and Technology*, (1), 1-8.

- Kasso, M., & Bekele, A. (2018). Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia. *Journal of the Saudi Society of Agricultural Sciences*, 17(1), 88-96.
- Kemble, J. M., Quesada-Ocampo, L. M., Ivors, K. L., Jennings, K. M., & Walgenbach, J. F. (2014). Southeastern US 2014 vegetable crop handbook.
- Kenny, O., Smyth, T. J., Hewage, C. M., & Brunton, N. P. (2013). Antioxidant properties and quantitative UPLC-MS analysis of phenolic compounds from extracts of fenugreek (*Trigonella foenum-graecum*) seeds and bitter melon (*Momordica charantia*) fruit. *Food chemistry*, 141(4), 4295-4302.
- Kereth, G. A., Lyimo, M., Mbwana, H. A., Mongi, R. J., & Ruhembe, C. C. (2013). Assessment of post-harvest handling practices: knowledge and losses of fruits in Bagamoyo district of Tanzania. *Food Science and Quality Management*, 11.
- Kerje, T., & Grum, M. (2000, March). The origin of melon, *Cucumis melo*: a review of the literature. In *VII Eucarpia Meeting on Cucurbit Genetics and Breeding 510* (pp. 37-44).
- Khalid, W., Ikram, A., Rehan, M., Afzal, F. A., Ambreen, S., Ahmad, M., ... & Sadiq, A. (2021). Chemical composition and health benefits of melon seed: A review. *Pakistan Journal of Agricultural Research*, 34(2), 309-317.
- Khaliq, G., Mohamed, M. T. M., Ali, A., Ding, P., & Ghazali, H. M. (2015). Effect of gum arabic coating combined with calcium chloride on physico-chemical and qualitative

- properties of mango (*Mangifera indica* L.) fruit during low temperature storage. *Scientia Horticulturae*, 190, 187-194.
- Khaliq, G., Nisa, M., Ramzan, M., & Koondhar, N. (2017). Textural properties and enzyme activity of mango (*Mangifera indica* L.) fruit coated with chitosan during storage. *Journal of Agricultural Studies*, 5(2), 32-50.
- Khaliq, G., Ramzan, M., & Baloch, A. H. (2019). Effect of Aloe vera gel coating enriched with *Fagonia indica* plant extract on physicochemical and antioxidant activity of sapodilla fruit during postharvest storage. *Food chemistry*, 286, 346-353.
- Khan, F. A., Bhat, S. A., & Narayan, S. (2017). Storage Methods for Fruits and Vegetables. *Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. Shalimar*.
- Kiaya, V. (2014). Post-harvest losses and strategies to reduce them. *Technical Paper on Postharvest Losses, Action Contre la Faim (ACF)*, 25, 1-25.
- Kimaro, E., Msogoya, T., Municipality, T., & Salaam-Tanzania, D. E. (2012, September). Postharvest losses of mangro fruit (*Mangifera indica*) in Morogoro Region. In *Proceedings of the RUFORUM 3rd Biennial Conference, Entebbe, Uganda* (pp. 24-28).
- Kitinoja, L., 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*, 91(4), 597-603.

- Kumar, N., Neeraj, Pratibha, & Singla, M. (2020). Enhancement of storage life and quality maintenance of litchi (*Litchi chinensis* Sonn.) fruit using chitosan: Pullulan blend antimicrobial edible coating. *International Journal of Fruit Science*, 20(sup3), S1662-S1680.
- Kumar, V., Purbey, S. K., & Anal, A. K. D. (2016). Losses in litchi at various stages of supply chain and changes in fruit quality parameters. *Crop Protection*, 79, 97-104.
- Kyriacou, M. C., Leskovar, D. I., Colla, G., & Roupael, Y. (2018). Watermelon and melon fruit quality: The genotypic and agro-environmental factors implicated. *Scientia Horticulturae*, 234, 393-408.
- Lamprey, S. (2013). *Assessment Of The Physical, Chemical And Organoleptic Characteristics Of Watermelon (*Citrullus Lanatus* [THUNB]) Waxed With Different Plant Oils* (Doctoral dissertation, University of Ghana).
- Lara, I., Belge, B., & Goulao, L. F. (2014). The fruit cuticle as a modulator of postharvest quality. *Postharvest Biology and Technology*, 87, 103-112.
- Lee, D., Yoo, J. H., & Lee, B. C. (2018). Therapeutic effect of *Cucumis melo* L. extract on insulin resistance and the gut microbiome in Lepob/Lepob mice. *Evidence-Based Complementary and Alternative Medicine*, 2018.
- Li, L., Pan, H., Chen, M., Zhang, S., & Zhong, C. (2017). Isolation and identification of pathogenic fungi causing postharvest fruit rot of kiwifruit (*Actinidia chinensis*) in China. *Journal of Phytopathology*, 165(11-12), 782-790.

- Li, X., Zhu, X., Wang, H., Lin, X., Lin, H., & Chen, W. (2018). Postharvest application of wax controls pineapple fruit ripening and improves fruit quality. *Postharvest Biology and Technology*, *136*, 99-110.
- Li, Z., & Thomas, C. (2014). Quantitative evaluation of mechanical damage to fresh fruits. *Trends in Food Science & Technology*, *35*(2), 138-150.
- Lima, E. N., Oster, A. H., Bordallo, P. N., Araújo, A. A., Silva, D. E., & Lima, C. S. (2021). A novel lineage in the *Fusarium incarnatum-equiseti* species complex is one of the causal agents of *Fusarium* rot on melon fruits in northeast Brazil. *Plant Pathology*, *70*(1), 133-143.
- Liu, W. (2014). Effect of different temperatures and parameters analysis of the storage life of fresh cucumber and tomato using controlled atmosphere technology. *American Journal of Food Technology*, *9*(2), 117-126.
- Lü, Q., & Tang, M. (2012). Detection of hidden bruise on kiwi fruit using hyperspectral imaging and parallelepiped classification. *Procedia Environmental Sciences*, *12*, 1172-1179.
- Luan, F., Delannay, I., & Staub, J. E. (2008). Chinese melon (*Cucumis melo* L.) diversity analyses provide strategies for germplasm curation, genetic improvement, and evidentiary support of domestication patterns. *Euphytica*, *164*(2), 445-461.
- Lufu, R., Berry, T. M., Ambaw, A., & Opara, U. L. (2017, September). The influence of liner packaging on weight loss and decay of pomegranate fruit. In *VII International*

- Conference on Managing Quality in Chains (MQUIC2017) and II International Symposium on Ornamentals in 1201* (pp. 259-264).
- Luo, D., Pang, X., Xu, X., Bi, S., Zhang, W., & Wu, J. (2018). Identification of cooked off-flavor components and analysis of their formation mechanisms in melon juice during thermal processing. *Journal of agricultural and food chemistry*, 66(22), 5612-5620.
- Macedo, S. D. S., QUEIRÓZ, M. A. D., AQUINO, I. P. F. D., OLIVEIRA, R. S. D., & LIMA, I. D. S. (2017). Botanical identification and genetic diversity in melons from family farming in the state of Maranhão. *Revista Caatinga*, 30, 602-613.
- Maftoonazad, N., Ramaswamy, H. S., & Marcotte, M. (2008). Shelf-life extension of peaches through sodium alginate and methyl cellulose edible coatings. *International Journal of Food Science and Technology*, 43(6), 951-957. <https://doi.org/10.1111/j.1365-2621.2006.01444.x>
- Magwaza, L. S., & Opara, U. L. (2015). Analytical methods for determination of sugars and sweetness of horticultural products—A review. *Scientia Horticulturae*, 184, 179-192.
- Mahajan, B. V. C., Tandon, R., Kapoor, S., & Sidhu, M. K. (2018). Natural coatings for shelf-life enhancement and quality maintenance of fresh fruits and vegetables—A review. *J. Postharvest Technol*, 6(1), 12-26.
- Mahajan, P. V., Caleb, O. J., Singh, Z., Watkins, C. B., & Geyer, M. (2014). Postharvest treatments of fresh produce. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 372(2017), 20130309.

Mahajan, P. V., Caleb, O. J., Singh, Z., Watkins, C. B., & Geyer, M. (2014). Postharvest treatments of fresh produce. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 372(2017), 20130309.10.1098/rsta.2013.0309 [[Crossref](#)], [[PubMed](#)], [[Web of Science®](#)], [[Google Scholar](#)]

Mahdikhani, M., & Davoodi, A. (2016). Evaluation of biocontrol potential of rhizosphere antagonist bacterial strains on Fusarium wilt and plant growth in muskmelon plants. *American-Eurasian Journal of Sustainable Agriculture*, 10(6), 15-24.

Mahfoudhi, N., & Hamdi, S. (2015). Use of Almond Gum and Gum Arabic as Novel Edible Coating to Delay Postharvest Ripening and to Maintain Sweet Cherry (*Prunus avium*) Quality during Storage. *Journal of Food Processing and Preservation*, 39(6), 1499-1508.

Mahomoodally, M. F. (2013). Traditional medicines in Africa: an appraisal of ten potent African medicinal plants. *Evidence-Based Complementary and Alternative Medicine*, 2013.

Maietti, A., Tedeschi, P., Stagno, C., Bordiga, M., Travaglia, F., Locatelli, M., ... & Brandolini, V. (2012). Analytical traceability of melon (*Cucumis melo* var *reticulatus*): proximate composition, bioactive compounds, and antioxidant capacity in relation to cultivar, plant physiology state, and seasonal variability. *Journal of food science*, 77(6), C646-C652.

- Mailafia, S., Okoh, G. R., Olabode, H. O. K., & Osanupin, R. (2017). Isolation and identification of fungi associated with spoilt fruits vended in Gwagwalada market, Abuja, Nigeria. *Veterinary World*, *10*(4), 393–397. <https://doi.org/10.14202/vetworld.2017.393-397>
- Maina, B., Ambuko, J., Hutchinson, M. J., & Owino, W. O. (2019). The effect of waxing options on shelf life and postharvest quality of “ngowe” mango fruits under different storage conditions. *Advances in Agriculture*, 2019.
- Mallek-Ayadi, S., Bahloul, N., & Kechaou, N. (2017). Characterization, phenolic compounds and functional properties of Cucumis melo L. peels. *Food chemistry*, *221*, 1691-1697.
- Mallek-Ayadi, S., Bahloul, N., & Kechaou, N. (2017). Characterization, phenolic compounds and functional properties of Cucumis melo L. peels. *Food chemistry*, *221*, 1691-1697.
- Mandal, D., Sailo, L., Hazarika, T. K., & Shukla, A. C. (2018). Effect of edible coating on shelf life and quality of local mango cv. Rangkuai of Mizoram. *Res. Crops*, *19*, 419-24.
- Mandal, D., Sailo, L., Hazarika, T. K., & Shukla, A. C. (2018). Effect of edible coating on shelf life and quality of local mango cv. Rangkuai of Mizoram. *Res. Crops*, *19*, 419-24.
- Maniwara, P., Boonyakiat, D., Poonlarp, P. B., Natwichai, J., & Nakano, K. (2015). Changes of postharvest quality in passion fruit (*Passiflora edulis* Sims) under modified atmosphere packaging conditions. *International Food Research Journal*, *22*(4).

- Martin, L. B., & Rose, J. K. (2014). There's more than one way to skin a fruit: formation and functions of fruit cuticles. *Journal of Experimental Botany*, 65(16), 4639-4651.
- Martínez-Romero, D., Albuquerque, N., Valverde, J. M., Guillén, F., Castillo, S., Valero, D., & Serrano, M. (2006). Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: a new edible coating. *Postharvest Biology and Technology*, 39(1), 93-100.
- Mashau, M. E., Moyane, J. N., & Jideani, I. A. (2012). Assessment of postharvest losses of fruits at Tshakhuma fruit market in Limpopo Province, South Africa. *African Journal of Agricultural Research*, 7(29), 4145-4150.
- McCREIGHT, J. D., NERSON, H., & GRUMET, R. (1993). Melon: Cucumis melo L. In *Genetic improvement of vegetable crops* (pp. 267-294). Pergamon.
- Mebratie, M. A., Haji, J., Woldetsadik, K., Ayalew, A., & Ambo, E. (2015). Determinants of postharvest banana loss in the marketing chain of central Ethiopia. *Food Science and Quality Management*, 37, 52-63.
- Mensah, M., & Fosu-Mensah, B. Y. (2020). Agriculture and gender roles in the semi-arid region of Ghana. *West African Journal of Applied Ecology*, 28(1), 144-157.
- Min, Z., Chunli, L., Yanjun, H., Qian, T., & Haiou, W. (2001). Preservation of fresh grapes at ice-temperature-high-humidity. *International agrophysics*, 15(2).
- Mir, S. A., Shah, M. A., Mir, M. M., Dar, B. N., Greiner, R., & Roohinejad, S. (2018). Microbiological contamination of ready-to-eat vegetable salads in developing countries

- and potential solutions in the supply chain to control microbial pathogens. *Food Control*, 85, 235-244.
- Mitcham, B., Cantwell, M., Kader, A. (1996). Methods of determination quality of fresh commodities. *Perishable Handling Newsletter*. Issue No.85, p 1-5.
- Mohamed-Nour, I. A., & Abu-Goukh, A. B. A. (2013). Effect of maleic hydrazide and waxing on ripening and quality of guava (*Psidium guajava* L.) fruit. *Gezira Journal of Agricultural Science*, 11(1).
- Mugonola, B., Deckers, J., Poesen, J., Isabirye, M., & Mathijs, E. (2013). Adoption of soil and water conservation technologies in the Rwizi catchment of south western Uganda. *International journal of agricultural sustainability*, 11(3), 264-281.
- Muhammad, R. M., & Masdek, N. R. N. M. (2016). Overview of melon industry in Malaysia. *Selangor: Malaysian Agricultural Research and Development Institute (MARDI)*.
- Mukhtar, A., Damerow, L., & Blanke, M. (2014). Non-invasive assessment of glossiness and polishing of the wax bloom of European plum. *Postharvest biology and technology*, 87, 144-
- Murthy, D. S., Gajanana, T. M., Sudha, M., & Dakshinamoorthy, V. (2009). Marketing and post-harvest losses in fruits: its implications on availability and economy. *Indian Journal of Agricultural Economics*, 64(902-2016-67302).

Mwangi, M., & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and sustainable development*, 6(5).

Nasirifar, S. Z., Maghsoudlou, Y., & Oliyaei, N. (2018). Effect of active lipid-based coating incorporated with nanoclay and orange peel essential oil on physicochemical properties of *Citrus sinensis*. *Food Science & Nutrition*, 6(6), 1508-1518.

Nath, A., Mangaraj, S., Goswami, T. K., & Chauhan, J. (2016). *Post harvest management and production of important horticultural crops*. Scientific Publishers.

Nath, A., Meena, L. R., Kumar, V., & Panwar, A. S. (2018). Postharvest management of horticultural crops for doubling farmer's income.

Nath, S., & Sil, S. (2008). Preservation and Storage of Perishable Fresh Fruits and Vegetables in the Lowlands of Papua New Guinea. *Ama, Agricultural Mechanization in Asia, Africa & Latin America*, 39(4), 75.

Nayik, G. A., & Muzaffar, K. (2014). Developments in packaging of fresh fruits-shelf life perspective: A review. *American Journal of Food Science and Nutrition Research*, 1(5), 34-39.

Nayik, G. A., Majid, I., & Kumar, V. (2015). *Developments in Edible films and Coatings for the extension of Shelf Life of Fresh Fruits*. 2(1), 16-20.  
<https://doi.org/10.12966/ajnfs.01.03.2015>

- Nayik, G. A., Majid, I., & Kumar, V. (2015). Developments in edible films and coatings for the extension of shelf life of fresh fruits. *American journal of nutrition and food science*, 2(1), 16-20.
- Nishijima, W. T. (1993, November). Effect of hot-air and hot-water treatments of papaya fruits on fruits quality and incidence of diseases. In *International Symposium on Tropical Fruits 370* (pp. 121-128).
- Njombolwana, N. S., Erasmus, A., Van Zyl, J. G., du Plooy, W., Cronje, P. J., & Fourie, P. H. (2013). Effects of citrus wax coating and brush type on imazalil residue loading, green mould control and fruit quality retention of sweet oranges. *Postharvest Biology and Technology*, 86, 362-371.
- Nunes, M. C. N., Emond, J. P., Rauth, M., Dea, S., & Chau, K. V. (2009). Environmental conditions encountered during typical consumer retail display affect fruit and vegetable quality and waste. *Postharvest Biology and Technology*, 51(2), 232-241.
- Nunez-Palenius, H. G., Gomez-Lim, M., Ochoa-Alejo, N., Grumet, R., Lester, G., & Cantliffe, D. J. (2008). Melon fruits: genetic diversity, physiology, and biotechnology features. *Critical reviews in biotechnology*, 28(1), 13-55.
- Offei, S. K., Cornelius, E. W., & Sakyi-Dawson, O. (2008). Crop diseases in Ghana and their management.
- Oliveira, P. M. D., Leite Júnior, B. R. D. C., Martins, M. L., Martins, E. M. F., & Ramos, A. M. (2014). Minimally processed yellow melon enriched with probiotic bacteria.

- Oliveira, V. R. L., Santos, F. K. G., Leite, R. H. L., Aroucha, E. M. M., & Silva, K. N. O. (2018). Use of biopolymeric coating hydrophobized with beeswax in post-harvest conservation of guavas. *Food chemistry*, 259, 55-64.
- Olorunnisola, A. O., & Okanlawon, S. A. (2017). Development of passive evaporative cooling systems for tomatoes Part 1: construction material characterization. *Agricultural Engineering International: CIGR Journal*, 19(1), 178-186.
- ömer AZABAĞAOĞLU, M. (2018). Investigating fresh fruit and vegetables losses at contemporary food retailers. *Sosyal Bilimler Araştırma Dergisi*, 7(4), 55-62.
- Omorogbe, I., Aina, O. S., Yakubu, S. A., & Hassan, A. A. (2017). Socio-economic Determinants of Sweet Melon Production in Balanga Local Government Area of Gombe State, Nigeria. *J Biodivers Endanger Species*, 5(180), 2.
- Ong'ute, H. W. (2019). *Pollination and guttation in sweet melon Cucumis melo l. grown under field and greenhouse conditions in Nairobi country, Kenya* (Doctoral dissertation, Kenyatta University).
- Opara, U. L., & Pathare, P. B. (2014). Bruise damage measurement and analysis of fresh horticultural produce—A review. *Postharvest Biology and Technology*, 91, 9-24.
- Orishagbemi, C. O., Opega, J. L., Amanabo, L., & Abuh, A. M. (2015). Biochemical properties and nutrient composition of some indigenous tropical fruits as affected by coating/waxing preservation. *Journal of Scientific Research and Reports*, 5(1), 47-57.

- Ortiz-Duarte, G., Pérez-Cabrera, L. E., Artés-Hernández, F., & Martínez-Hernández, G. B. (2019). Ag-chitosan nanocomposites in edible coatings affect the quality of fresh-cut melon. *Postharvest Biology and Technology*, *147*, 174-184.
- Osaе, R., Essilfie, G., & Anim, J. O. (2017). Assessment of locally produced waxing materials on the shelf life and fruit quality of two tomato varieties (*Solanum lycopersicum*). *Journal of Energy and Natural Resource Management*, *4*(1).
- Osaе, R., Essilfie, G., & Anim, J. O. (2017). Assessment of locally produced waxing materials on the shelf life and fruit quality of two tomato varieties (*Solanum lycopersicum*). *Journal of Energy and Natural Resource Management*, *4*(1).
- Oster, A. H., SILVA, E. D. O., BORDALLO, P. D. N., Zocolo, G. J., da SILVEIRA, M. R. S., Oiram Filho, F., & de ARAÚJO, A. A. C. (2018). Luz ultravioleta pulsada no controle de podridão pós-colheita e na qualidade de melão para exportação.
- Oyeleke, W. A., & Odedeji, J. O. (2011). Effect of different waxing material on some chemical properties, minerals and antinutrients compositions of pawpaw (*Carica papaya*). *Pakistan Journal of Nutrition*.
- Ozturk, B., Kucuker, E., Karaman, S., & Ozkan, Y. (2012). The effects of cold storage and aminoethoxyvinylglycine (AVG) on bioactive compounds of plum fruit (*Prunus salicina* Lindell cv. 'Black Amber'). *Postharvest Biology and Technology*, *72*, 35-41.
- Padmaperuma, G., Butler, T. O., Shuhaili, F. A. A., Almalki, W. J., & Vaidyanathan, S. (2020). Microbial consortia: concept and application in fruit crop management. In *Fruit crops* (pp. 353-366). Elsevier.

Panghal, A., Yadav, D. N., Khatkar, B. S., Sharma, H., Kumar, V., & Chhikara, N. (2018). Post-harvest malpractices in fresh fruits and vegetables: food safety and health issues in India. *Nutrition & Food Science*.

Panghal, A., Yadav, D. N., Khatkar, B. S., Sharma, H., Kumar, V., & Chhikara, N. (2018). Post-harvest malpractices in fresh fruits and vegetables: food safety and health issues in India. *Nutrition & Food Science*.

Park, H. J., M. S. Chinnan, R. L. Shewfelt, (1994). Edible coating effects on storage life and quality of tomatoes. *J. Food Sci.*, 59: p. 568-570.

Parveen, A., Mazhari, B. B. Z., & Rao, S. (2016). Impact of bio-nanogold on seed germination and seedling growth in *Pennisetum glaucum*. *Enzyme and Microbial Technology*, 95, 107-111.

Pedreschi, R., & Lurie, S. (2015). Advances and current challenges in understanding postharvest abiotic stresses in perishables. *Postharvest Biology and Technology*, 107, 77-89.

Petkova, Z., & Antova, G. (2015). Proximate composition of seeds and seed oils from melon (*Cucumis melo* L.) cultivated in Bulgaria. *Cogent Food & Agriculture*, 1(1), 1018779.

Petracek, P. D., Dou, H., & Pao, S. (1998). The influence of applied waxes on postharvest physiological behavior and pitting of grapefruit. *Postharvest Biology and Technology*, 14(1), 99-106.

- Pinzon, M. I., Sanchez, L. T., Garcia, O. R., Gutierrez, R., Luna, J. C., & Villa, C. C. (2020). Increasing shelf life of strawberries (*Fragaria ssp*) by using a banana starch-chitosan-Aloe vera gel composite edible coating. *International Journal of Food Science & Technology*, 55(1), 92-98.
- Pitrat, M., Hanelt, P., & Hammer, K. (2000, March). Some comments on infraspecific classification of cultivars of melon. In *VII Eucarpia Meeting on Cucurbit Genetics and Breeding 510* (pp. 29-36).
- Pobiega, K., Kraśniewska, K., & Gniewosz, M. (2019). Application of propolis in antimicrobial and antioxidative protection of food quality – A review. *Trends in Food Science and Technology*, 83(November 2018), 53–62. <https://doi.org/10.1016/j.tifs.2018.11.007>
- Prasad, K., Jacob, S., & Siddiqui, M. W. (2018). Fruit maturity, harvesting, and quality standards. In *Preharvest Modulation of Postharvest Fruit and Vegetable Quality* (pp. 41-69). Academic Press.
- Prasad, K., Jacob, S., & Siddiqui, M. W. (2018). Fruit maturity, harvesting, and quality standards. In *Preharvest Modulation of Postharvest Fruit and Vegetable Quality* (pp. 41-69). Academic Press.
- Ramaswamy, H. S. (2014). *Post-harvest technologies of fruits & vegetables*. DEStech Publications, Inc.
- Ramees, T. P., Dhama, K., Karthik, K., Rathore, R. S., Kumar, A., Saminathan, M., ... & Singh, R. K. (2017). *Arcobacter*: an emerging food-borne zoonotic pathogen, its public health

- concerns and advances in diagnosis and control—a comprehensive review. *Veterinary Quarterly*, 37(1), 136-161.
- Ramjan, M. D., & Ansari, M. T. (2018). Factors affecting of fruits, vegetables and its quality. *J. Med. Plants*, 6, 16-18.
- Rathore, H. A., Masud, T., Sammi, S., & Soomro, A. H. (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety Dosehari. *Pakistan journal of Nutrition*, 6(2), 143-148.
- Razavi, F., & Hajilou, J. (2016). Enhancement of postharvest nutritional quality and antioxidant capacity of peach fruits by preharvest oxalic acid treatment. *Scientia Horticulturae*, 200, 95-101.
- Reczek, C. R., & Chandel, N. S. (2015). Revisiting vitamin C and cancer. *Science*, 350(6266), 1317-1318.
- 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.
- Rodríguez-Pérez, C., Quirantes-Piné, R., Fernández-Gutiérrez, A., & Segura-Carretero, A. (2013). Comparative characterization of phenolic and other polar compounds in Spanish melon cultivars by using high-performance liquid chromatography coupled to electrospray ionization quadrupole-time of flight mass spectrometry. *Food Research International*, 54(2), 1519-1527.

- Rokaya, P. R., Baral, D. R., Gautam, D. M., Shrestha, A. K., & Paudyal, K. P. (2016). Effect of postharvest treatments on quality and shelf life of mandarin (*Citrus reticulata* Blanco). *American Journal of Plant Sciences*, 7(07), 1098.
- Rolim, P. M., Seabra, L. M. A. J., & de Macedo, G. R. (2020). Melon by-products: Biopotential in human health and food processing. *Food Reviews International*, 36(1), 15-38.
- Saeed, K. (2012). *Causes of postharvest losses of mango and shea fruits in Northern Ghana, West Africa* (Doctoral dissertation, Master's Dissertation, Ghent University, Belgium).
- Saeed, M. T., Saleem, M., Usmani, S., Malik, I. A., Al-Shammari, F. A., & Deen, K. M. (2019). Corrosion inhibition of mild steel in 1 M HCl by sweet melon peel extract. *Journal of King Saud University-Science*, 31(4), 1344-1351.
- Saftner, R., Polashock, J., Ehlenfeldt, M., & Vinyard, B. (2008). Instrumental and sensory quality characteristics of blueberry fruit from twelve cultivars. *Postharvest Biology and Technology*, 49(1), 19-26.
- Salman, M. A. M. (2005). *Biological Control of Rhizopus Soft Rot on Apple, Pear and Peach by Trichoderma harzianum* (Doctoral dissertation).
- Saltveit, M. E. (1999). Effect of ethylene on quality of fresh fruits and vegetables. *Postharvest biology and technology*, 15(3), 279-292.
- Sánchez-González, M. J., Sánchez-Guerrero, M. C., Medrano, E., Porras, M. E., Baeza, E. J., & Lorenzo, P. (2015). Influence of pre-harvest factors on quality of a winter cycle, high commercial value, tomato cultivar. *Scientia Horticulturae*, 189, 104-111.

- Sang, N. (2020). Effect of ratio of bees wax and carnauba wax in mixed wax on respiration rate, weight loss, fruit decay and chemical quality of vietnamese passion fruits during low temperature storage. *Pakistan Journal of Biotechnology*, 17(2), 63-70.
- Sawicka, B. (2019). Post-harvest losses of agricultural produce. In Springer Nature Switzerland AG, Zero Hunger (pp. 654–669). Springer.
- Sebastian, P., Schaefer, H., Telford, I. R., & Renner, S. S. (2010). Cucumber (*Cucumis sativus*) and melon (*C. melo*) have numerous wild relatives in Asia and Australia, and the sister species of melon is from Australia. *Proceedings of the National Academy of Sciences*, 107(32), 14269-14273.
- Semiz, A., & Sen, A. (2007). Antioxidant and chemoprotective properties of *Momordica charantia* L.(bitter melon) fruit extract. *African journal of Biotechnology*, 6(3).
- Shahi, N. C., Lohani, U. C., Chand, K., & Singh, A. (2012). Effect of pre-cooling treatments on shelf life of tomato in ambient condition. *International Journal of Food, Agriculture and Veterinary Sciences*, 2(3), 50-56.
- Shahid, M. N., & Abbasi, N. A. (2011). Effect of bee wax coatings on physiological changes in fruits of sweet orange CV.“blood red”. *Sarhad Journal of Agriculture*, 27(3), 385-394.
- Shahid, M. N., & Abbasi, N. A. (2011b). Effect of bee wax coatings on physiological changes in fruits of sweet orange CV.“blood red”. *Sarhad Journal of Agriculture*, 27(3), 385-394.

- Shankar, K., Singh, S. K., Kumar, D., Varshney, S., Gupta, A., Rajan, S., ... & Gaikwad, A. N. (2015). Cucumis melo ssp. agrestis var. agrestis ameliorates high fat diet induced dyslipidemia in Syrian golden hamsters and inhibits adipogenesis in 3T3-L1 adipocytes. *Pharmacognosy magazine*, *11*(Suppl 4), S501.
- Sheahan, M., & Barrett, C. B. (2017). Food loss and waste in Sub-Saharan Africa: A critical review. *Food Policy*, *70*(1), 1-12.
- Shee, A., Mayanja, S., Simba, E., Stathers, T., Bechoff, A., & Bennett, B. (2019). Determinants of postharvest losses along smallholder producers maize and Sweetpotato value chains: an ordered Probit analysis. *Food Security*, *11*(5), 1101-1120.
- Shewfelt, R. L., & Prussia, S. E. (2022). Challenges in handling fresh fruits and vegetables. In *Postharvest Handling* (pp. 167-186). Academic Press.
- Shi, J. X., Porat, R., Goren, R., & Goldschmidt, E. E. (2005). Physiological responses of 'Murcott' mandarins and 'Star Ruby' grapefruit to anaerobic stress conditions and their relation to fruit taste, quality and emission of off-flavor volatiles. *Postharvest Biology and Technology*, *38*(2), 99-105.
- Singh V, Hedayetullah M, Zaman P, Meher J (2014). Postharvest technology of fruit and vegetables: An Overview. *Journal of Post-Harvest Technology* 2:124-135.
- Singh, D., & Sharma, R. R. (2018). Postharvest diseases of fruits and vegetables and their management. In *Postharvest disinfection of fruits and vegetables* (pp. 1-52). Academic Press.

- Singh, S., Khemariya, P., Rai, A., Rai, A. C., Koley, T. K., & Singh, B. (2016). Carnauba wax-based edible coating enhances shelf-life and retain quality of eggplant (*Solanum melongena*) fruits. *LWT*, 74, 420-426.
- Sripong, K., Srinon, T., Ketkaew, K., Uthairatakij, A., & Jitareerat, P. (2020, June). Impacts of paraffin wax and propolis on controlling crown rot disease and maintaining postharvest quality of banana. In *IOP Conference Series: Earth and Environmental Science* (Vol. 515, No. 1, p. 012036). IOP Publishing.
- Stropek, Z., & Gołacki, K. (2015). A new method for measuring impact related bruises in fruits. *Postharvest Biology and Technology*, 110, 131-139.
- Subratty, A. H., Gurib-Fakim, A., & Mahomoodally, F. (2005). Bitter melon: an exotic vegetable with medicinal values. *Nutrition & Food Science*.
- Sugri, I., Norman, J. C., Egyir, I., & Johnson, P. N. T. (2010). Preliminary assessment of shea butter waxing on the keeping and sensory qualities of four plantain (*Musa aab*) varieties. *Afr. J. Agric. Res*, 5(19), 2676-2684.
- Suvedi, M., Ghimire, R., & Kaplowitz, M. (2017). Farmers' participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis. *The Journal of Agricultural Education and Extension*, 23(4), 351-371.
- Swamy, M. V. M., Kumar, N. V., & Kamatyanatti, M. (2020). Use of several edible natural coatings on kinnow (*Citrus reticulata* Blanco) fruit. *IJCS*, 8(6), 1969-1972.

- Tabatabaekolour, R. (2013). Engineering properties and bruise susceptibility of peach fruits (*Prunus persica*). *Agricultural Engineering International: CIGR Journal*, 15(4), 244-252.
- Tadmor, Y., Burger, J., Yaakov, I., Feder, A., Libhaber, S. E., Portnoy, V., ... & Katzir, N. (2010). Genetics of flavonoid, carotenoid, and chlorophyll pigments in melon fruit rinds. *Journal of agricultural and food chemistry*, 58(19), 10722-10728.
- Tavassoli-Kafrani, E., Shekarchizadeh, H., & Masoudpour-Behabadi, M. (2016). Development of edible films and coatings from alginates and carrageenans. *Carbohydrate polymers*, 137, 360-374.
- Thakur, R., Pristijono, P., Golding, J. B., Stathopoulos, C. E., Scarlett, C. J., Bowyer, M., ... & Vuong, Q. V. (2018). Development and application of rice starch based edible coating to improve the postharvest storage potential and quality of plum fruit (*Prunus salicina*). *Scientia horticulturae*, 237, 59-66.
- Tucker, G., Yin, X., Zhang, A., Wang, M., Zhu, Q., Liu, X., ... & Grierson, D. (2017). Ethylene and fruit softening. *Food Quality and Safety*, 1(4), 253-267.
- Valencia-chamorro, S. A., Oficial, A., & Oficial, A. (2015). Antifungal Edible Coatings for Fresh Citrus Fruit: A Review. 962–986. <https://doi.org/10.3390/coatings5040962>
- Valero, D., Díaz-Mula, H. M., Zapata, P. J., Guillén, F., Martínez-Romero, D., Castillo, S., & Serrano, M. (2013). Effects of alginate edible coating on preserving fruit quality in four plum cultivars during postharvest storage. *Postharvest Biology and Technology*, 77, 1-6.

- Van Gorkom, G. N., Klein Wolterink, R. G., Van Elssen, C. H., Wieten, L., Germeraad, W. T., & Bos, G. M. (2018). Influence of vitamin C on lymphocytes: an overview. *Antioxidants*, 7(3), 41.
- Vanoli, M., Grassi, M., Buccheri, M., & Rizzolo, A. (2015). Influence of edible coatings on postharvest physiology and quality of Honeydew melon fruit (*Cucumis melo L. inodorus*). *Advances in Horticultural Science*, 29(2/3), 65-74.
- Veena, A., K. Nagendra Babu, and H. R. Venkatesha. "Supply Chain: A Differentiator in Marketing Fresh Produce." *IUP Journal of Supply Chain Management* 8.1 (2011).
- Veraverbeke, E. A., Verboven, P., Van Oostveldt, P., & Nicolai, B. M. (2003). Prediction of moisture loss across the cuticle of apple (*Malus sylvestris* subsp. *Mitis* (Wallr.)) during storage: part 1. Model development and determination of diffusion coefficients. *Postharvest Biology and Technology*, 30(1), 75-88.
- Vishwakarma, V. K., Gupta, J. K., & Upadhyay, P. K. (2017). Pharmacological importance of *Cucumis melo L.*: An overview. *Asian Journal of Pharmaceutical and Clinical Research*, 8-12.
- Vishwakarma, V. K., Gupta, J. K., & Upadhyay, P. K. (2017). Pharmacological importance of *Cucumis melo L.*: An overview. *Asian Journal of Pharmaceutical and Clinical Research*, 8-12.
- Vouldoukis, I., Lacan, D., Kamate, C., Coste, P., Calenda, A., Mazier, D., & Dugas, B. (2004). Antioxidant and anti-inflammatory properties of a *Cucumis melo LC*. extract rich in superoxide dismutase activity. *Journal of Ethnopharmacology*, 94(1), 67-75.

- Wang, H. H., Wang, Y., & Delgado, M. S. (2014). The transition to modern agriculture: Contract farming in developing economies. *American Journal of Agricultural Economics*, *96*(5), 1257-1271.
- Wang, J., Hao, H., Liu, R., Ma, Q., Xu, J., Chen, F., ... & Deng, X. (2014). Comparative analysis of surface wax in mature fruits between Satsuma mandarin (*Citrus unshiu*) and 'Newhall' navel orange (*Citrus sinensis*) from the perspective of crystal morphology, chemical composition and key gene expression. *Food Chemistry*, *153*, 177-185.
- Wei, X., Song, M., Chen, C., Tong, H., Liang, G., & Gmitter Jr, F. G. (2018). Juice volatile composition differences between Valencia orange and its mutant Rohde Red Valencia are associated with carotenoid profile differences. *Food chemistry*, *245*, 223-232.
- Wintergerst, E. S., Maggini, S., & Hornig, D. H. (2006). Immune-enhancing role of vitamin C and zinc and effect on clinical conditions. *Annals of Nutrition and Metabolism*, *50*(2), 85-94.
- Wisuthiphaet, N., Damerow, L., & Blanke, M. M. (2014). Non-destructive detection of the wax bloom on European plum during post-harvest handling. *Journal of Food Engineering*, *140*(September 2013), 46–51.  
<https://doi.org/10.1016/j.jfoodeng.2014.04.016>
- Wonglom, P., & Sunpapao, A. (2020). *Fusarium incarnatum* is associated with postharvest fruit rot of muskmelon (*Cucumis melo*). *Journal of Phytopathology*, *168*(4), 204-210.
- Wu, F., Groopman, J. D., & Pestka, J. J. (2014). Public health impacts of foodborne mycotoxins. *Annu. Rev. Food Sci. Technol*, *5*(1), 351-372.

- Wu, S. J., & Ng, L. T. (2008). Antioxidant and free radical scavenging activities of wild bitter melon (*Momordica charantia* Linn. var. *abbreviata* Ser.) in Taiwan. *LWT-Food Science and Technology*, *41*(2), 323-330.
- Xanthopoulos, G. T., Templalexis, C. G., Aleiferis, N. P., & Lentzou, D. I. (2017). The contribution of transpiration and respiration in water loss of perishable agricultural products: The case of pears. *Biosystems Engineering*, *158*, 76-85.
- Xu, D., Qin, H., & Ren, D. (2018). Prolonged preservation of tangerine fruits using chitosan/montmorillonite composite coating. *Postharvest Biology and Technology*, *143*, 50-57.
- Yahaya, S. M., Kamalu, A. B., Ali, M. U., Lawan, M., Ajingi, Y. S., Haruna, M., ... & Aisha, T. (2019). A study of pathogenic fungi causing post harvest losses of pineapple sold at Wudil and Yan Lemo markets of Kano State. *Journal of Experimental Agriculture International*, 1-6.
- Yahia, E. M., Fonseca, J. M., & Kitinoja, L. (2019). Postharvest losses and waste. *Postharvest technology of perishable horticultural commodities*, 43-69.
- Yahia, E. M., Fonseca, J. M., & Kitinoja, L. (2019). Postharvest losses and waste. *Postharvest technology of perishable horticultural commodities*, 43-69.
- Yahia, E. M., Ornelas-Paz, J. D. J., & Elansari, A. (2011). Postharvest technologies to maintain the quality of tropical and subtropical fruits. In *Postharvest biology and technology of tropical and subtropical fruits* (pp. 142-195e). Woodhead Publishing.

- Yahia, E. M., Ornelas-Paz, J. D. J., & Elansari, A. (2011). Postharvest technologies to maintain the quality of tropical and subtropical fruits. In *Postharvest biology and technology of tropical and subtropical fruits* (pp. 142-195e). Woodhead Publishing.
- Yang, G., Yue, J., Gong, X., Qian, B., Wang, H., Deng, Y., & Zhao, Y. (2014). Blueberry leaf extracts incorporated chitosan coatings for preserving postharvest quality of fresh blueberries. *Postharvest Biology and Technology*, *92*, 46-53.
- Yin, Y., Bi, Y., Chen, S., Li, Y., Wang, Y., Ge, Y., & Zhang, Z. (2011). Chemical composition and antifungal activity of cuticular wax isolated from Asian pear fruit (cv. Pingguoli). *Scientia Horticulturae*, *129*(4), 577-582.
- Zahedi, S. M., Hosseini, M. S., Karimi, M., & Ebrahimzadeh, A. (2019). Effects of postharvest polyamine application and edible coating on maintaining quality of mango (*Mangifera indica* L.) cv. Langra during cold storage. *Food Science & Nutrition*, *7*(2), 433-441.
- Zhang, L., Chen, F., Lai, S., Wang, H., & Yang, H. (2018). Impact of soybean protein isolate-chitosan edible coating on the softening of apricot fruit during storage. *LWT* *96*: 604–611.
- Zhang, S., Zheng, Q., Xu, B., & Liu, J. (2019). Identification of the fungal pathogens of postharvest disease on peach fruits and the control mechanisms of *Bacillus subtilis* JK-14. *Toxins*, *11*(6), 322.



## APPENDIX 1: QUESTIONNAIRES

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: Influence of Different Waxing Materials on the Physical, Chemical and Organoleptic Properties of Canary Yellow Melon (*Cucumis melo* Var. *Inodorus*)

---

---

Questionnaire No: ..... Date: .....

Respondents Name: ..... Contact No: .....

Location: .....

I am a student in the University of Ghana pursuing a Master of Philosophy Degree in Postharvest Technology. This questionnaire is meant to collect information for research purposes as part of the requirement for a master of philosophy degree. I would therefore be very grateful if you could willingly partake in this interview with the assurance that information obtained will be treated as confidential and be used solely for academic purposes. Thank you for participating.

### SECTION A – QUESTIONNAIRE FOR FARMERS ONLY

DEMOGRAPHY (Please tick [] where applicable)

General Information

1. Sex: Male [] Female []
2. Age range: Below 18 years [] 18 – 24 years [] 25 – 40[  ] 41 -55 years [] above 55 years []
3. Marital status: a) Married [] b) Single [] c) Widowed [] d) Divorced []  
e) Separated []

EDUCATIONAL BACKGROUND

- 4. What is your level of education? None  Primary  JHS/JSS  Middle school  Secondary  Technical/ Vocational  Certificate  Diploma/ Degree   
Other  (Please specify).....
- 5. What type(s) of work do you do in addition to farming?
  - a) Mason, construction work, etc
  - b) Artisan (blacksmith, carpentry, tailoring)
  - c) General trade in agricultural produce
  - d) General trade in non-agricultural produce
  - e) Student
  - f) Others(specify)
- 6. How long have you been farming? Below 6yrs  6 – 10 yrs  10 – 15 yrs  Above 16 yrs
- 7. What is the size of your farm?  
.....
- 8. How many times do you cultivate in a year? Once  Twice  Thrice
- 9. Where are seeds obtained from?
  - a) Own seeds
  - b) Fellow farmers or friends
  - c) Extension Agents (AEA)
  - d) Certified dealers/sellers
  - e) MOFA offices
  - f) Other (specify).....
- 10. Do you apply any agro-chemicals? a) Yes  b) No
- 11. In your opinion what are the practices that affect post- harvest quality?  
.....  
.....  
.....

HARVESTING AND POSTHARVEST PRACTICES

*Harvesting Operation*

- 12. Do you prearrange for market before harvesting? Yes  / No
- 13. At what time of the day do you usually harvest your produce?  
(a) Morning  (b) Afternoon  (c) Evening  (d) No specific time
- 14. Do you have any special reason for harvesting at a specific time of the day? Yes  / No

15. If yes, please explain?  
.....
16. At what stage of maturity do you harvest your produce?  
(a) Mature unripe [ ] (b) Half ripe [ ] (c) Yellow ripe [ ] (d) other [ ] (Please specify).....
17. How do you harvest your fruit? (a) Manual [ ] (b) Mechanical [ ]
18. If manual, please specify. a) By knife cutting [ ] b) by hand twisting [ ]
19. If mechanical indicate equipment use.  
.....  
.....
20. Do you incur some losses during harvesting? a) Yes [ ] b) No [ ]
21. If yes, what losses do you suffer? a) Mechanical [ ] b) Physiological [ ] c) Rotting [ ]

22. What is the estimate quantity of loss suffered?  
Please specify.....

*Losses at Storage and Storage Practices*

23. Is there a ready market for your produce? Yes [ ] / No [ ]
24. Where are fruits stored? a) On the farm b) at home c) other specify).....
25. How do you store your produce in case there is no ready market?  
(a) Stored in a specially conditioned storage facility [ ] (b) Poured on bare cemented floor [ ] (c) others [ ] (Please specify)  
.....  
.....
26. Briefly describe how fruits are stored  
.....  
.....  
.....  
.....
27. Describe the environment/conditions under which fruits are stored  
.....  
.....  
.....  
.....

28. Is the storage method chosen usually able to store your produce to prevent / reduce spoilage? Yes [ ] / No [ ]
29. If “Yes”, did you acquire this knowledge through a special training in storage? Yes [ ] /No [ ]
30. If yes, where did you get this special training?  
(a) School [ ] (b) Farmer’s forum [ ] (c) MoFA farmers’ field day [ ] (d) Traditional [ ]  
(e) Other [ ] (Please specify).....
31. Are you willing to adopt innovative storage methods if they prove more effective than what you currently use? Yes [ ] / No [ ]
32. What are the major challenges you face during storage?  
.....
33. Do you incur some losses during Storage? a) Yes [ ] b) No [ ]
34. If yes, what losses do you suffer? a) Mechanical [ ] b) physiological [ ] c) Rotting [ ]
35. What is the estimate quantity of loss suffered? Please specify.....

Losses at Packaging and Packaging Practices

36. What packaging material do you use for your produce? (a) Shallow wooden boxes [ ] b) Long big wooden boxes [ ] (c) Plastic basket [ ] d) cane basket [ ]  
e) Other [ ] (please specify).....
37. Do you subject the produce to any special condition(s) before packaging them for market? Yes [ ] / No [ ]
38. If “Yes”, can you share it/them with us?  
.....
39. Do you incur some losses during Packaging? a) Yes [ ] b) No [ ]
40. What is the estimate quantity of loss suffered?  
Please specify.....
41. What type of losses do you incur during packing?  
a) Mechanical [ ] b) physiological [ ] c) Rotting [ ]

Farmers Perception on Waxing of Canary Yellow Melon Fruit after Harvest.

42. Do you know of waxing?

(a)Yes [ ] (b) No [ ]

43. Do you employ waxing to your canary yellow melon fruits after harvest? (a)Yes [ ] (b) No [ ]
44. If “Yes”, what are your reasons for using the waxing material in storage of the canary yellow melon fruit after harvest?  
.....  
.....
45. What type of waxing material do you use? (a) Sheabutter [ ] b) Paraffin wax oil [ ] c) Palm kernel oil [ ] d) Coconut oil [ ] e) Any other specify.....
46. Do you know any modern storage technology of canary yellow melon fruit after harvest? Yes [ ] No.
47. Would you change your method of preservation if another method is proven to be more effective? a) Yes [ ] b) No [ ]

Postharvest Losses and Practices

48. In your opinion where do you think most of the losses occur from the point of harvest to the point of sale? a) Harvesting [ ] b) Sorting [ ] c) Storage [ ] d) Packaging [ ] e) Transporting [ ] f) Marketing [ ]  
g) Other [ ] (please specify).....
49. Describe the type of loses incurred.  
.....  
.....  
.....
50. What is the estimate quantity of loss suffered?  
Please specify.....
51. What are the various causes of postharvest losses of canary yellow melon in your community? (Tick as many as applicable)
- a. Lack of market avenues [ ] b. Unreliable means of transport to move produce to market [ ] c. Lack of adequate storage facilities [ ] d. Lack of adequate storage technology [ ]  
e. Non-exposure to modern trends of canary yellow melon production [ ] f. Lack of processing plants [ ]  
g. Limited alternative uses of the produce [ ] h. Other [ ] (Please specify).....
52. Which of the following forms of losses do you incur? a. Bruises [ ] b. Rot [ ] c. theft [ ] d. Other [ ] (Please specify).....

53. Do you receive any form of help from Agric Extension Agents (AEA's)

Yes [ ] No [ ]

54. If yes, describe the nature and type of services you receive from extension agents?

.....  
.....  
.....  
.....

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: Influence of Different Waxing Materials on the Physical, Chemical and Organoleptic Properties of Canary Yellow Melon (*Cucumis melo* Var. *Inodorus*)

---

Questionnaire No: ..... Date: .....

Respondents Name: ..... Contact No: .....

Location: .....

I am a student in the University of Ghana pursuing a Master of Philosophy Degree in Postharvest Technology. This questionnaire is meant to collect information for research purposes as part of the requirement for a master of philosophy degree. I would therefore be very grateful if you could willingly partake in this interview with the assurance that information obtained will be treated as confidential and be used solely for academic purposes. Thank you for participating.

**QUESTIONNAIRE FOR TRADERS (WHOLESALE/RETAILERS)**

DEMOGRAPHY (Please tick [√] where applicable)

General Information

1. Sex: Male [ ] Female [ ]
2. Age range: Below 18 years [ ] 18 – 24 yrs [ ] 25 – 40yrs [ ] 41 -55 yrs [ ] above 55 yrs [ ]
3. Marital status a) Married [ ] b) Single [ ] c) Widowed [ ] d) Divorced [ ] e) Separated [ ]

4. What is your level of education? None  Primary  JHS/JSS  Middle school  Secondary  Technical/ Vocational  Certificate  Diploma/ Degree  Other  (Please specify).....
5. How long have you been trading in canary yellow melon? (a) Below 1 year  (b) 1 – 4 years  (c) 5 – 8 years  (d) Over 8 years
6. How would you assess the rate of canary yellow melon spoilage in your area over the years? a) Very high  b) High  c) Low  d) Very low  e) Stable  f) Reducing
7. Which of the following accounts for the losses? (Tick as many as applicable)  
(a) Lack of ready market  (b) Lack of transport of produce  (c) Lack of storage facility  (d) Lack of storage technology  (e) Pest attack  (f) others  (Please specify).....
8. Where do you obtain your fruits from? (a) Own farm  (b) Purchase from farmers  (c) Purchase from wholesalers  (d) Purchase from retailers
9. How do you usually transport purchased produce to your point of sale?  
a) By vehicle  b) By any available head-loaded porter   
c) Any other .....
10. What type of vehicle do you use to transport your produce?  
a) Open truck  b) Van or roofed truck  c) Other   
Please specify: .....
11. What materials are used to cover fruits during transportation?  
a) Tarpaulin  b) Black polyethene sheets  c) Straw  d) No cover  e) Other   
Please specify: .....
12. In your opinion how would you rate the condition of your vehicle in transporting the goods? a) Very good  b) Good  c) Average  d) Bad  e) Very bad
13. In your own assessment, what is the condition of the road network that you use? a) Very good  b) Good  c) Average  d) Bad  e) Very bad
14. Where are fruits stored? a) At the market  b) At home   
c) In a warehouse/store room  d) Other (specify).....
15. How are fruits stored?  
.....  
.....  
.....  
.....  
.....

16. Describe the environment/conditions under which fruits are stored  
.....  
.....  
.....  
.....
17. What is/are the major challenge(s) encountered during storage of the fruits?  
a) Insect  b) rodents  c) rot  d) thieves  e) weight loss   
f) Other (specify)
18. Do you incur commodity losses from the point of purchase to the point of sale?  
a) Yes  b) No
19. If “yes”, what losses do you suffer? a) Quantitative loss  b) Qualitative loss
20. In your opinion where do you think most of the losses occur from the point of purchase to the point of sale?  
a) .....  
b) .....  
c) .....
21. What is the estimate quantity of loss suffered?  
Please specify.....
22. Do you perform any form of preservation? a) Yes  b) No
23. If “Yes” Please give reasons  
.....  
.....  
.....  
.....
24. Did you learn this skill from a special training? Yes  / No
25. From which organization did you get this training? (a) Traders association  (b) MoFA staff  (c) NGO  (d) Others   
Please specify).....
26. Do you know of waxing? (a) Yes  (b) No
27. Do you employ waxing in the storage of your canary yellow melon fruits?  
(a) Yes  (b) No
28. If “Yes”, what are your reasons for using the waxing material in storage of the canary yellow melon fruit?  
.....  
.....

29. What type of waxing material do you use? a) Shea butter [ ] b) Paraffin wax oil [ ] c) Palm kernel oil [ ] d) Coconut oil [ ]  
e) Any other specify.....
30. Do you know any effective modern storage technology of canary yellow melon fruit that can extend it shelf life and improve it quality? a) Yes [ ] b) No [ ]
31. If “Yes”, state.  
.....  
.....  
.....
32. Would you change your method of preservation if another method is proven to be more effective? a) Yes [ ] b) No [ ]

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: Influence of Different Waxing Materials on the Physical, Chemical and Organoleptic Properties of Canary Yellow Melon (*Cucumis melo* Var. *Inodorus*)

Name.....Sex.....

.....

Contact..... Date..... Sample code.....

Please you are receiving coded samples of canary yellow melon evaluated under different waxing formulations for their keeping and sensory qualities. Make your individual assessment /judgment after a moderate amount of observation and consideration. You give a more objective assessment by scoring without consulting fellow assessor/panellist. Take a sip of water, pause for a while before testing the next sample. Please score the samples as best as possible using the scale below.

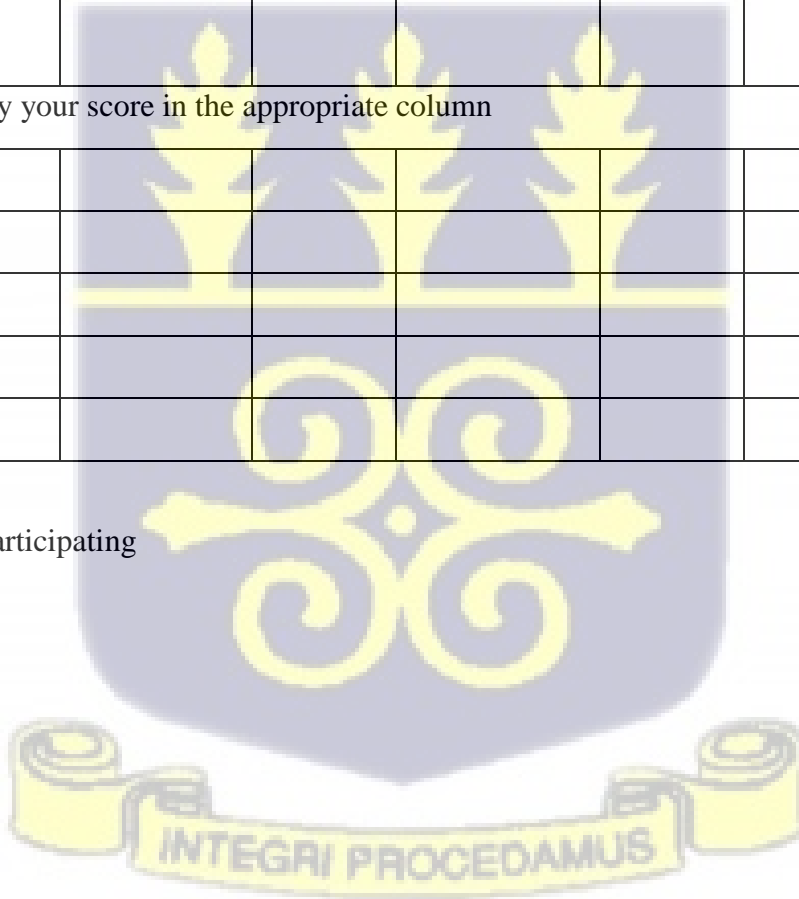
Score	Skin/rind colour	Glossiness (rind)	Attractiveness (rind)	Taste (sweetness)	Flavour (characteristic) smell and aroma	Mouth feel	Pulp colour	Texture	Overall acceptability

5	Very bright	Extremely glossy	Extremely attractive	Extremely sweet	Very pleasant	Like extremely	Extremely white	Very crunchy	Like extremely
4	bright	Very glossy	Very attractive	Very sweet	pleasant	Like very much	Very white	crunchy	Like much
3	dull	Glossy	attractive		unpleasant	Like	white	Slightly crunchy	Like
2	Very dull	Slightly glossy	unattractive	Slightly sweet	slightly unpleasant	dislike	Slightly white	soft	dislike
1	Extremely dull	Not glossy	Very unattractive	Not sweet	very unpleasant	Dislike very much	Off colour	Very soft	Dislike much

Please write or tick boldly your score in the appropriate column

5									
4									
3									
2									
1									

Thank you for participating



## APPENDIX 2: ANOVA TABLES

### ANOVA 1. VARIATE: 3DAS % WEIGHT LOSS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	14.231625	2.033089	889.05	<.001
Residual	16	0.036589	0.002287		
Total	23	14.268214			

### ANOVA 2. VARIATE: 6DAS % WEIGHT LOSS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	193.519	27.646	17.19	<.001
Residual	16	25.728	1.608		
Total	23	219.247			

### ANOVA 3. VARIATE: 9DAS % WEIGHT LOSS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	302.89856	43.27122	444.47	<.001
Residual	16	1.55769	0.09736		
Total	23	304.45625			

### ANOVA 4. VARIATE: 12DAS % WEIGHT LOSS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	275.1344	39.3049	270.95	<.001
Residual	16	2.3210	0.1451		

---

Total	23	277.4554
-------	----	----------

---

ANOVA 5. VARIATE: 15DAS % WEIGHT LOSS

---

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	970.917	138.702	76.63	<.001
Residual	16	28.962	1.810		
Total	23	999.879			

---

ANOVA 6. VARIATE: 18DAS % WEIGHT LOSS

---

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	423.5560	60.5080	73.86	<.001
Residual	16	13.1074	0.8192		
Total	23	436.6634			

---

ANOVA 7. VARIATE: 3DAS FIRMNESS

---

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	8.238	1.177	1.07	0.427
Residual	16	17.640	1.103		
Total	23	25.878			

---

ANOVA 8. VARIATE: 6DAS FIRMNESS

---

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	112.379	16.054	12.47	<.001

---

Residual	16	20.607	1.288
Total	23	132.985	

ANOVA 9. VARIATE: 9DAS FIRMNESS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	463.3538	66.1934	80.36	<.001
Residual	16	13.1791	0.8237		
Total	23	476.5329			

ANOVA 10. VARIATE: 12DAS FIRMNESS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	377.9101	53.9872	83.14	<.001
Residual	16	10.3893	0.6493		
Total	23	388.2994			

ANOVA 11. VARIATE: 15DAS FIRMNESS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	121.4508	17.3501	88.66	<.001
Residual	16	3.1312	0.1957		
Total	23	124.5820			

ANOVA 12. VARIATE: 18DAS FIRMNESS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	7.55653	1.07950	56.73	<.001

Residual	16	0.30447	0.01903
Total	23	7.86100	

ANOVA 13. VARIATE: 3DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	0.65612	0.09373	1.23	0.341
Residual	16	1.21447	0.07590		
Total	23	1.87058			

ANOVA 14. VARIATE: 6DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	2.0789	0.2970	0.91	0.520
Residual	16	5.1968	0.3248		
Total	23	7.2757			

ANOVA 15. VARIATE: 9DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	0.1691	0.0242	0.21	0.977
Residual	16	1.8070	0.1129		
Total	23	1.9760			

ANOVA 16. VARIATE: 12DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	100.208450	14.315493	1639.18	<.001

Residual	16	0.139733	0.008733
Total	23	100.348183	

ANOVA 17. VARIATE: 15DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	241.888717	34.555531	5657.11	<.001
Residual	16	0.097733	0.006108		
Total	23	241.986450			

ANOVA 18. VARIATE: 18DAS pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	101.013529	14.430504	7480.17	<.001
Residual	16	0.030867	0.001929		
Total	23	101.044396			

ANOVA 19. VARIATE: 3DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	7.7017	1.1002	1.15	0.384
Residual	16	15.3433	0.9590		
Total	23	23.0450			

ANOVA 20. VARIATE: 6DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	8.0833	1.1548	2.09	0.105

Residual	16	8.8267	0.5517
Total	23	16.9100	

ANOVA 21. VARIATE: 9DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	9.468	1.353	0.59	0.758
Residual	16	36.967	2.310		
Total	23	46.435			

ANOVA 22. VARIATE: 12DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	63.9579	9.1368	86.16	<.001
Residual	16	1.6967	0.1060		
Total	23	65.6546			

ANOVA 23. VARIATE: 15DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	112.1800	16.0257	91.47	<.001
Residual	16	2.8033	0.1752		
Total	23	114.9833			

ANOVA 24. VARIATE: 18DAS TOTAL SOLUBLE SOLIDS

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	95.5529	13.6504	58.06	<.001

Residual	16	3.7617	0.2351
Total	23	99.3146	

ANOVA 25. VARIATE: 3DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	1787.0	255.3	1.27	0.323
Residual	16	3205.7	200.4		
Total	23	4992.7			

ANOVA 26. VARIATE: 6DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	6294.8	899.3	3.54	0.017
Residual	16	4060.1	253.8		
Total	23	10354.9			

ANOVA 27. VARIATE: 9DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	1531.1	218.7	1.17	0.370
Residual	16	2980.1	186.3		
Total	23	4511.2			

ANOVA 28. VARIATE: 12DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	25499.1	3642.7	18.21	<.001

Residual	16	3200.2	200.0
Total	23	28699.3	

ANOVA 29. VARIATE: 15DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	12417.85	1773.98	38.10	<.001
Residual	16	745.04	46.56		
Total	23	13162.89			

ANOVA 30. VARIATE: 18DAS TOTAL TITRABLE ACIDITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	4318.139	616.877	361.00	<.001
Residual	16	27.341	1.709		
Total	23	4345.480			

ANOVA 31. VARIATE: 0DAS VITAMIN C CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	0.00	0.00	0.00	1.000
Residual	8	172.13	21.52		
Total	15	172.13			

ANOVA 32. VARIATE: 4DAS VITAMIN C CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	259.346	37.049	6.22	0.010

Residual	8	47.657	5.957
Total	15	307.003	

ANOVA 33. VARIATE: 8DAS VITAMIN C CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	233.931	33.419	27.43	<.001
Residual	8	9.747	1.218		
Total	15	243.679			

ANOVA 34. VARIATE: 12DAS VITAMIN C CONTENT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	221.593	36.932	24.94	<.001
Residual	7	10.366	1.481		
Total	13	231.959			

ANOVA 35. VARIATE: 0DAS SKIN COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	2.5875	0.3696	1.89	0.084
Residual	72	14.1000	0.1958		
Total	79	16.6875			

ANOVA 36. VARIATE: 4DAS SKIN COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	5.8875	0.8411	8.07	<.001

Residual	72	7.5000	0.1042
Total	79	13.3875	

ANOVA 37. VARIATE: 8DAS SKIN COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	7.5500	1.0786	6.47	<.001
Residual	72	12.0000	0.1667		
Total	79	19.5500			

ANOVA 38. VARIATE: 12DAS SKIN COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	1.5714	0.2619	1.14	0.351
Residual	63	14.5000	0.2302		
Total	69	16.0714			

ANOVA 39. VARIATE: 0DAS TEXTURE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	14.5875	2.0839	11.63	<.001
Residual	72	12.9000	0.1792		
Total	79	27.4875			

ANOVA 40. VARIATE: 4DAS TEXTURE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	7.9500	1.1357	4.65	<.001

Residual	72	17.6000	0.2444
Total	79	25.5500	

ANOVA 41. VARIATE: 8DAS TEXTURE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	12.3500	1.7643	7.22	<.001
Residual	72	17.6000	0.2444		
Total	79	29.9500			

ANOVA 42. VARIATE: 12DAS TEXTURE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	5.5714	0.9286	5.57	<.001
Residual	63	10.5000	0.1667		
Total	69	16.0714			

ANOVA 43. VARIATE: 0DAS TASTE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	4.9875	0.7125	3.27	0.005
Residual	72	15.7000	0.2181		
Total	79	20.6875			

ANOVA 44. VARIATE: 4DAS TASTE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	3.8000	0.5429	4.16	<.001

Residual	72	9.4000	0.1306
Total	79	13.2000	

ANOVA 45. VARIATE: 8DAS TASTE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	3.1875	0.4554	2.23	0.041
Residual	72	14.7000	0.2042		
Total	79	17.8875			

ANOVA 46. VARIATE: 12DAS TASTE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	3.8000	0.6333	3.07	0.011
Residual	63	13.0000	0.2063		
Total	69	16.8000			

ANOVA 47. VARIATE: 0DAS PULP COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	2.95000	0.42143	5.23	<.001
Residual	72	5.80000	0.08056		
Total	79	8.75000			

ANOVA 48. VARIATE: 8DAS PULP COLOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	5.60000	0.80000	36.00	<.001

Residual	72	1.60000	0.02222
Total	79	7.20000	

ANOVA 49. VARIATE: 0DAS MOUTH FEEL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	9.0000	1.2857	8.27	<.001
Residual	72	11.2000	0.1556		
Total	79	20.2000			

ANOVA 50. VARIATE: 4DAS MOUTH FEEL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	4.4000	0.6286	4.71	<.001
Residual	72	9.6000	0.1333		
Total	79	14.0000			

ANOVA 51. VARIATE: 8DAS MOUTH FEEL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	8.1500	1.1643	10.75	<.001
Residual	72	7.8000	0.1083		
Total	79	15.9500			

ANOVA 52. VARIATE: 12DAS MOUTH FEEL

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	3.8857	0.6476	5.16	<.001

Residual	63	7.9000	0.1254
Total	69	11.7857	

ANOVA 53. VARIATE: 0DAS GLOSSINESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	11.7500	1.6786	5.54	<.001
Residual	72	21.8000	0.3028		
Total	79	33.5500			

ANOVA 54. VARIATE: 4DAS GLOSSINESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	17.6000	2.5143	14.37	<.001
Residual	72	12.6000	0.1750		
Total	79	30.2000			

ANOVA 55. VARIATE: 8DAS GLOSSINESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	20.2875	2.8982	25.76	<.001
Residual	72	8.1000	0.1125		
Total	79	28.3875			

ANOVA 56. VARIATE: 12DAS GLOSSINESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
---------------------	------	------	------	------	-------

TREATMENT	6	1.5714	0.2619	2.36	0.041
Residual	63	7.0000	0.1111		
Total	69	8.5714			

ANOVA 57. VARIATE: 0DAS FLAVOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	15.8000	2.2571	10.16	<.001
Residual	72	16.0000	0.2222		
Total	79	31.8000			

ANOVA 58. VARIATE: 4DAS FLAVOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	12.6000	1.8000	12.23	<.001
Residual	72	10.6000	0.1472		
Total	79	23.2000			

ANOVA 59. VARIATE: 8DAS FLAVOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	11.0000	1.5714	14.51	<.001
Residual	72	7.8000	0.1083		
Total	79	18.8000			

ANOVA 60. VARIATE: 12DAS FLAVOUR

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
---------------------	------	------	------	------	-------

TREATMENT	6	11.2000	1.8667	12.92	<.001
Residual	63	9.1000	0.1444		
Total	69	20.3000			

ANOVA 61. VARIATE: 0DAS ATTRACTIVENESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	14.8875	2.1268	13.55	<.001
Residual	72	11.3000	0.1569		
Total	79	26.1875			

ANOVA 62. VARIATE: 4DAS ATTRACTIVENESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	18.9500	2.7071	10.48	<.001
Residual	72	18.6000	0.2583		
Total	79	37.5500			

ANOVA 63. VARIATE: 8DAS ATTRACTIVENESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	12.18750	1.74107	50.14	<.001
Residual	72	2.50000	0.03472		
Total	79	14.68750			

ANOVA 64. VARIATE: 12DAS ATTRACTIVENESS OF RIND

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	6	1.5714	0.2619	2.26	0.049

Residual	63	7.3000	0.1159
Total	69	8.8714	

ANOVA 65. VARIATE: 0DAS OVERALL ACCEPTABILITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	7.28750	1.04107	10.86	<.001
Residual	72	6.90000	0.09583		
Total	79	14.18750			

ANOVA 66. VARIATE: 4DAS OVERALL ACCEPTABILITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	2.18750	0.31250	9.00	<.001
Residual	72	2.50000	0.03472		
Total	79	4.68750			

ANOVA 67. VARIATE: 8DAS OVERALL ACCEPTABILITY

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	7	9.60000	1.37143	61.71	<.001
Residual	72	1.60000	0.02222		
Total	79	11.20000			

