

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
KUMASI, GHANA COLLEGE OF AGRICULTURE AND NATURAL
RESOURCES FACULTY OF AGRICULTURE**

DEPARTMENT OF HORTICULTURE

KNUST

**INFLUENCE OF DIFFERENT MODES OF TRANSPORTATION SYSTEMS ON
THE POSTHARVEST QUALITY CHARACTERISTICS OF WATERMELON
(*Citrullus Lanatus*) IN THE TAMALE METROPOLITAN AREA IN THE
NORTHERN REGION OF GHANA**

BY

VICTOR ATMONING YAKUBU

APRIL, 2016

**INFLUENCE OF DIFFERENT MODES OF TRANSPORTATION SYSTEMS ON
THE POSTHARVEST QUALITY CHARACTERISTICS OF WATERMELON
(*Citrullus lanatus*) IN THE TAMALE METROPOLITAN AREA IN THE
NORTHERN REGION OF GHANA**

KNUST

BY VICTOR ATMONING YAKUBU

**A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE
STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND
TECHNOLOGY, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR
THE DEGREE OF MASTER OF PHILOSOPHY (MPhil POSTHARVEST
TECHNOLOGY)**

APRIL, 2016

ACKNOWLEDGEMENTS

This study would not have been a reality without the support of others in terms of material, intellectual and emotional support. I, therefore, express my sincere gratitude to God for His abundant Grace. To Him alone be the glory, honour and praise for the needed strength and enablement to carry out this study. I also owe a great debt of gratitude and appreciation to my supervisors, Dr. Francis Appiah and Mr. Paul Yaw Adjei of the Department of Horticulture, KNUST, for their rich suggestions, corrections and direction given to me in the process of this work. They have been meticulous, patient and helpful. I am really very grateful to them.

Again, I thank the following personalities for their emotional, material and prayer support. They are Mr. Mohammed Sulley an Officer of Nsuta District Education Office for his immense contributions and suggestions, Mr. Mohammed Adam Nashiru President of the Peasant Farmers Association of Ghana, and Stephen Akanlug Yakubu.

Finally, I am grateful to all those who gave me various kinds of support in relation to this work especially the leadership of Watermelon Traders Association in Tamale during the administration of the questionnaire and some staff of the Savannah Agricultural Research Institute at Nyankpala. I appreciate your support and may the good Lord God bless you.

DEDICATION

This thesis is dedicated to my father Mr. S. K. Yakubu, a retired Police Sargent Major; my mother, Madam Lariba Akpabiik; my beloved family and farmers

KNUST



ABSTRACT

The high perishability of fruits and vegetables in the agricultural sector is a major concern to scientists and the various stakeholders along the value chain. Postharvest handling practices and transportation systems among others are some of the factors leading to an appreciable amount of postharvest losses. This study therefore sought to determine the influence of different modes of transportation systems on the postharvest quality characteristics of watermelon (*Citrullus lanatus*) in the Tamale metropolitan, in the Northern region of Ghana. The study was conducted in two phases. Phase 1 assessed the handling and management of watermelon and Phase 2 assessed the chemical and physical qualities of the watermelon varieties (Crimson Sweet, Charleston and Sweet Baby) after using different modes of transportation. Combination of purposive and convenient sampling strategies was used to select 50 respondents for questionnaire administration. From the field survey, it was observed that majority (60%) of the water melon traders sourced their watermelon at the farm gate while twenty-four (24%) and sixteen percent (16%) respectively obtained their watermelon from wholesalers and retailers. The two major problems faced by the watermelon traders were storage facility (25.70%) and mechanical damages (74.30%). Cracks (26.90%) and bruises (73.10%) were the major contributing factors to the mechanical damage. After different modes of transportation, the moisture ranged between 91.00% - 96%, TSS ranged between 6.96% - 8.56% and pH from 5.07% - 5.30%. The bruises on the fruits increased from between 2.00% - 4.33% to 15.66% - 25.66% while the cracks increased from between 1.00% -2.33% to 3.66% -8.00%. Water melon fruits were affected by mode of transportation, especially, the Crimson Sweet variety transported in the tricycle (motor king). The tricycle can, however, be roofed to prevent the dropping off of the fruits and also lined to prevent mechanical injuries inflicted on the fruits during transportation.

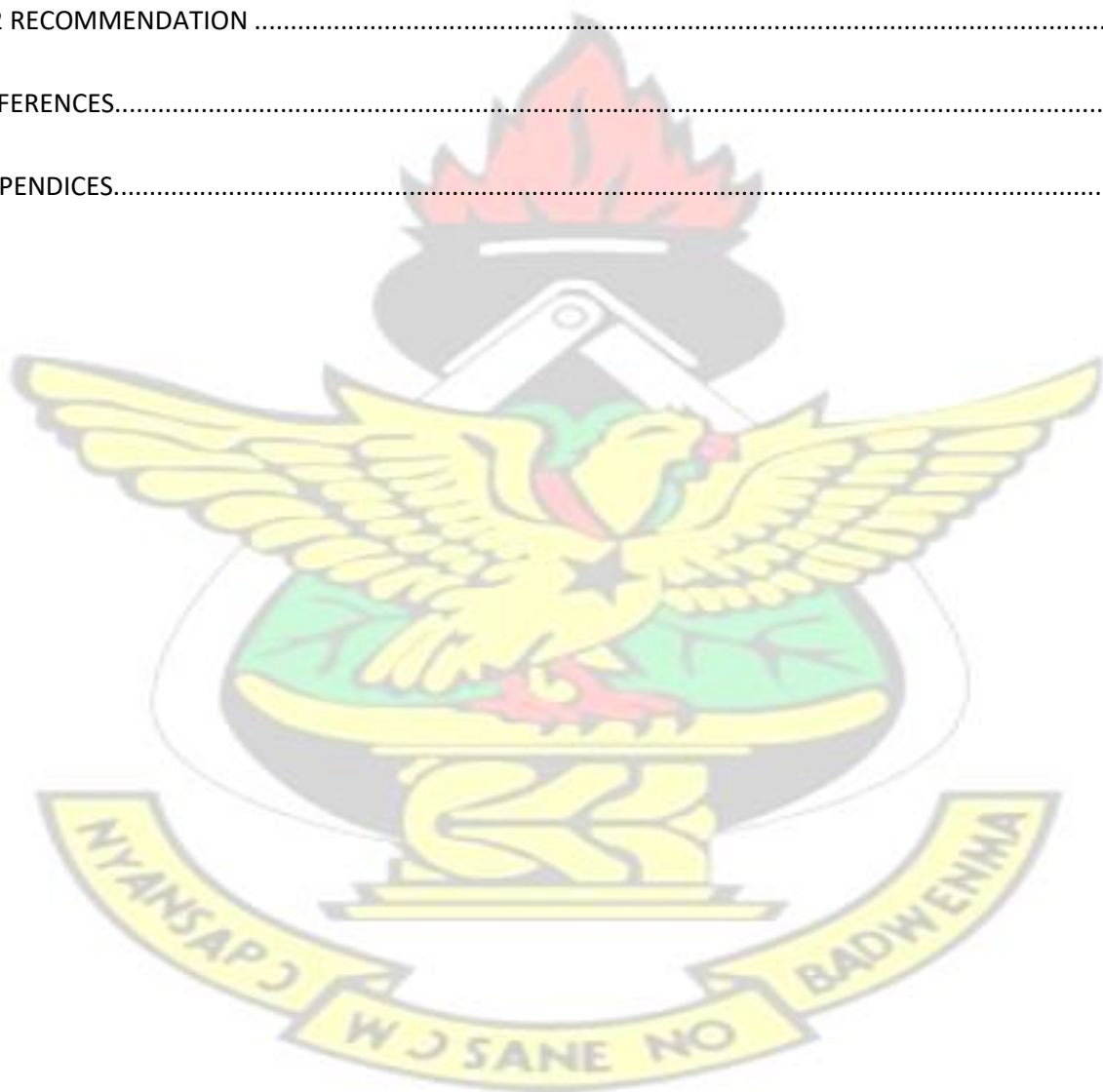
TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENTS.....	ii
DEDICATION.....	
iii	
ABSTRACT.....	
iv CHAPTER ONE	
.....	9
1.0 INTRODUCTION.....	9
CHAPTER TWO	
.....	13
2.0 LITERATURE REVIEW.....	13
2.1 ORIGIN AND DISTRIBUTION OF WATERMELON.....	13
2.2 VARIETIES OF WATERMELON.....	13
2.3 HEALTH BENEFITS OF WATERMELON.....	14
2.4 QUALITY CHARACTERISTICS OF WATERMELON FRUIT	15
2.4.1 Total Soluble Solids Content (TSS)	
.....	15
2.4.2 pH, Total Titratable Acids and Moisture content of Watermelon.....	16
2.4.3 Moisture content of Watermelon.....	17
2.5 HARVEST AND POSTHARVEST HANDLING OF WATERMELON.....	18
2.6 POSTHARVEST LOSSES OF WATERMELON.....	19
2.6.1 Colour and Flavour Changes	
.....	20

2.6.2 Pathological Disorder.....	20
2.6.3 Insect Pests of Watermelon.....	21
2.6.4 Physical Disorders of Watermelon.....	21
2.6.4.1 Mechanical injuries.....	21
2.6.4.2 Skin abrasion.....	22
2.6.4.3 Watermelon fruit cracks	23
CHAPTER THREE.....	25
3.0 MATERIALS AND METHODS.....	25
3.1 STUDY AREA.....	25
3.2 RESEARCH DESIGN	25
3.2.1 Field Survey.....	25
3.2.2 Questionnaire Design and Administration.....	25
3.3 SAMPLING OF WATERMELON FRUITS	26
3.4 MODE OF TRANSPORTATION.....	26
3.5 EXPERIMENTAL DESIGN	27
3.6 LABORATORY WORK	27
3.7 DETERMINATION OF SOME QUALITY CHARACTERSTICS	27
3.7.1 Moisture Content.....	27
3.7.2 Mechanical Damage.....	27
3.7.3 Total Soluble Solids (TSS)	28
3.7.4 Total Titratable Acidity (TTA)	28
3.7.5 pH.....	28
3.8 DATA ANALYSIS.....	28
CHAPTER FOUR	29

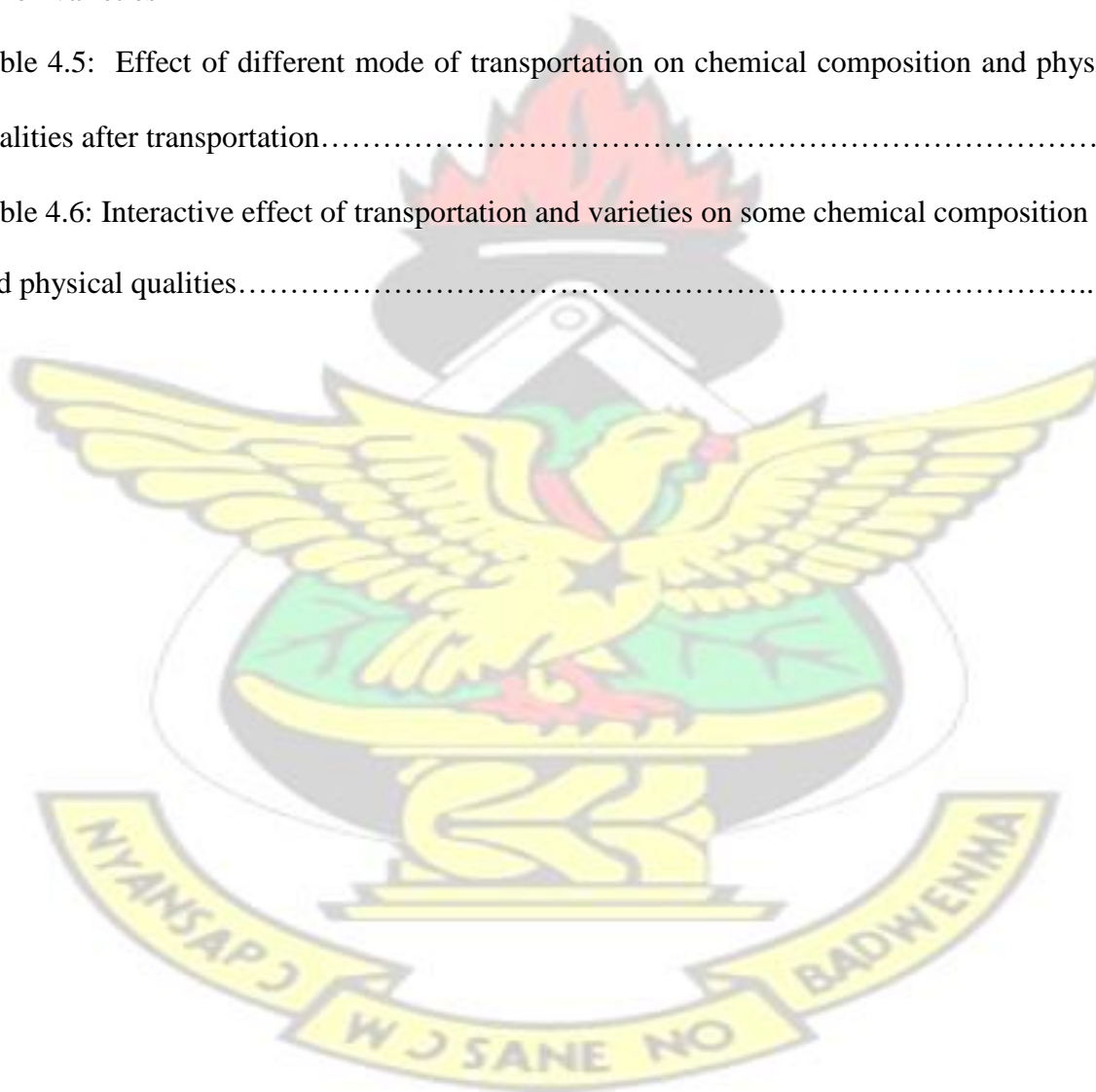
4.0 RESULTS.....	29
4.1 FIELD SURVEY.....	29
4.1.1 Demographic Information of Water melon traders	29
4.2 LABORATORY ANALYSIS	33
4.2.1 Chemical composition and physical qualities of water melon before transportation	33
4.2.2 Effect of transportation on chemical composition and physical qualities of water melon varieties.....	34
4.2.3 Effect of different mode of transportation on chemical composition and physical qualities after transportation.....	35
4.2.4 Interactive effect of transportation and varieties on chemical composition and physical qualities of water melon.....	37
4.2.4.1 Moisture content	37
4.2.4.2 Total soluble solids.....	38
4.2.4.3 pH.....	38
4.2.4.4 Bruises.....	39
4.2.4.5 Cracks.....	39
CHAPTER FIVE	41
5.0 DISCUSSION.....	41
5.1 DEMOGRAPHIC INFORMATION OF THE WATERMELON TRADERS.....	41
5.2 MARKETING CHARACTERISTICS OF WATER MELON TRADERS	41
5.3 CHALLENGES ENCOUNTERED DURING TRANSPORTATION OF THE WATER MELON FRUITS.....	42
5.4 POSTHARVEST HANDLING PRACTICES	43
5.4.2 Pre-cooling.....	43
5.4.3 Sorting.....	43
5.5 CHEMICAL AND PHYSICAL QUALITIES BEFORE TRANSPORTATION	43
5.5.1 Moisture Content.....	43
5.5.2 Total Soluble Solids.....	44

5.5.3 Total Titratable Acidity.....	45
5.5.4 pH.....	46
5.5.5 Bruises.....	46
5.5.6 Cracks.....	47
CHAPTER SIX.....	48
6.0 CONCLUSION AND RECOMMENDATION.....	48
6.1 CONCLUSION.....	48
6.2 RECOMMENDATION	49
REFERENCES.....	50
APPENDICES.....	59



LIST OF TABLES

Table 4.1: Demographic Information of traders.....	23
Table 4.2: Traders Marketing Characteristics and Problems Encountered.....	24
Table 4.3: Chemical composition and physical qualities of watermelon before transportation.....	26
Table 4.4: Effects of transportation on chemical composition and physical qualities of watermelon varieties.....	27
Table 4.5: Effect of different mode of transportation on chemical composition and physical qualities after transportation.....	29
Table 4.6: Interactive effect of transportation and varieties on some chemical composition and physical qualities.....	32



CHAPTER ONE

1.0 INTRODUCTION

Watermelon (*Citrullus Lanatus*) belongs to the family Cucurbitaceae and genus *Citrullus* and it is the only cultivated species of this genus (Bisognin, 2002). Watermelon is an herbaceous plant found in the squash family (cucurbitaceous). They are annual plants with multi branched procumbent tendrils which bear vines and extensive rooting system. The roots are extensive but shallow with taproots (Pantastico, 1975).

The fruit is sweet and juicy and grown in warm climates all over the world (Robinson and Decker-Walker, 1997). According to Jeffery (2001), watermelon is an annual species consisting of cultivated, semi-domesticated and wild forms - widely distributed in tropical and subtropical areas. Watermelon contains fruit parts and plant parts. Every part contains different traits or characteristics which are needed by both consumers and growers. Such characteristics include flavour, texture, disease resistance and appearance such as shape and colour (Wehner *et al.*, 2001). Identification of watermelon varieties and determination of their genetic purity and relatedness relies mainly on fruit characteristics (Levin *et al.*, 2001). Morphological markers can be an effective means to determine genetic relatedness among cultivars and among selection and use in watermelon breeding programs.

A report by Levin *et al.* (2001), indicated that extensive variation in morphological characteristics exists among watermelon cultivars. These include rind colour and thickness, fruit shape and size, flesh texture and colour, sugar content, seed shape and color, day to fruit maturity and disease resistance. Most of these characteristics are quantitative traits affected by a single or a few gene mutations (Levin *et al.*, 2006). Watermelon is believed to have originated

in Africa (Tindal, 1983) but is now widely spread throughout the tropics and Mediterranean (Tindal, 1983). Wild watermelon (*Citrillus colocynthus*) was a native of arid soils in Africa at least 4,000 years ago and now grown worldwide particularly in regions with long hot summers (Robertson, 2004). Watermelon is an important horticultural crop mostly known for its sweet and juicy fruit (Robinson and Decker-Walters 1997; Jeffery, 2007). Watermelon is one of the most cultivated crops in the world (Huh *et al.*, 2008). Its global consumption is greater than that of any other cucurbit. It accounts for about 6.8% of the world area devoted to vegetable production (Guner and Wehner, 2004; Goreta *et al.*, 2005). China is the leading country in watermelon production, followed by Turkey, The United States, Iran and the Republic of Korea (Huh *et al.*, 2008; Wehner and Maynard 2003). Watermelon is mostly cultivated as an under sown intercrop together with cereals or root crop in the same ways as other cucurbits (Matanyaire 1998; Ikeorgu 1991).

In Africa, watermelon accounted for about 5.4% of the harvested area devoted to vegetable production in 2008 and this contributed to the world's watermelon production with 4.6% of 99,194,223 tons (FAOSTAT, 2008). Watermelon has different uses and farmers grow three different types which include dessert, seed and cooking types at the Northern Khalahari Desert (Maggs *et al.*, 2000). In West African countries, the use of watermelon seeds as a source of food has been reported (Loukou *et al.*, 2000), when they ripe, the sweet juicy pulp is eaten fresh and the rind is sometimes preserved (Silwana and Lucas, 2002). The seeds are roasted as snack or grounded into an ingredient in oils or sauces (Olurunda and Tung, 1985). Watermelons are thought to have been domesticated at first in the Southern and Central Africa where they were used as an important source of water and food articles especially among the resource poor areas (Jensen, 2012, Mujaju *et al.*, 2012).

In terms of the nutritional status, the importance of watermelon cannot be over emphasized.

Watermelon has become an important part of the healthy diet nutritionally. It is almost free of fat, sodium and cholesterol. The fruit contains 93-95% water, 5% carbohydrates, 0.5%-1% protein and 0.2% fat (Rubatzky and Yamaguchi, 1997). Watermelon is also an excellent source of beta-carotene and Vitamin C, while the seeds are high in Vitamin E and in the anti-oxidant minerals, Zinc and Selenium. Despite the importance of watermelon, the watermelon production system in Ghana is characterized by several constraints which include: incidence of pests and diseases; drought, flood, low soil fertility and inadequate inputs. Again the mode of transport used to convey the harvested watermelon fruit from the farm gates (production centres) to the marketing centres is another constraint which characterizes watermelon production in Ghana. Watermelon fruits are generally transported in open trucks or inside unrefrigerated vans. These medium of transportation is not ideal for maintaining fruit quality. The fruits on top of the load in open trucks are usually subjected to sunburns with fruits loaded inside enclosed vans subjected to overheating especially if transportation occurs during hot sunny afternoons (Rubatzky and Yamaguchi, 1997).

Watermelon shelf life of eight days has been extended by researchers through various research techniques. Unfortunately, this has been done without mechanical shocks and vibration impacts which are obviously encountered during commercial handling management system (Cartao *et al.*, 1997). Mechanical injuries sustained by fruits during handling are the main reason for the considerable decline of fresh fruits and vegetables production. This is due to damage in the chain between the grower and consumer which is estimated to be in the range 30%-40% (Peleg and Hinga, 1986). Whole fruits such as pears (Slaughter *et al.*, 1993) and peaches (Vergano *et*

al., 1991) are susceptible to vibration injury which appears as bruising, moisture loss and skin abrasion (Picha, 1988)

Watermelon has become one of the fruits eaten by many Ghanaian households. The cultivation of water melon is done in the hinter lands and transported to the urban markets for sale. The modes of transportation affect the quality of water melon. The high consumer demand for consumption of high quality fruits and vegetables in recent times has been a major debate in the global market. Additionally, producers and farmers crave to maximize profits through efficient production system. This will not be achieved if the appropriate transportation method is not used.

The main objective of this study was to determine the effects of different mode of transportation on the quality of watermelon fruits in Tamale, Northern Region of Ghana

The specific objectives of the study were to:

1. identify the various modes of transportation used by traders for conveying the harvested produce from the farm gates to the marketing centres;
2. identify the postharvest handling practices carried out by the respondents and
3. assess the effect of the different modes of transportation on the physico-chemical and mechanical properties of watermelon fruit after transportation to the marketing centres

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DISTRIBUTION OF WATERMELON

Watermelon (*Citrullus lanatus* [Thunb]) is an annual plant which belongs to the family *cucurbitaceae* and is believed to have originated from South-Africa where a wild variety is still found growing. Silwana and Lucas (2002) reported that there is evidence sufficient to prove that watermelon may be native to tropical Africa. The edible fruit is produced on trailing vines that may reach 4.6 m or more in length. Fruit vary in shape from globular to oblong. The rind colour varies in shades of green from pale yellow to almost black and may be solid, striped, or marbled. Fruits have a thin, firm outer rind, a layer of white-fleshed inner rind that may be up to about one-inch-thick, and an interior edible pulp containing seeds unless the variety is triploid. Pulp colour of most commercial varieties is some shade of red or yellow (Tindal, 1983). In Ghana, watermelon is distributed throughout the country. The cultivation of watermelon is concentrated along the southern sector of the country (Greater Accra region, Ashanti region, Volta region, Western, Central and Eastern region) with much emphasis on the coastal savannah plain of the southern sector of the country (Jeffery, 1975). Some of these areas include Ada, Weija, Kasoa, Ningo, Afiencya, Tsofoli, Sege, Nsakena, Winneba, Potsin, Nkoranza, Todze, Sogakofe, Akatsi and Adidome. In addition to this, certain areas of the middle belt i.e. some parts of the BrongAhafo region, Upper Volta and parts of the three northern regions is also under cultivation (Jeffery, 1975).

2.2 VARIETIES OF WATERMELON

All over the world, more than 1,200 varieties of watermelons are produced, with between 200 and 300 varieties grown in the United States alone (USDA, 1978). There are four basic groups

of watermelon varieties: Picnic, Ice-Box, Seedless, and Yellow-Flesh. The Picnic type is oblong in shape, have dark green skin/rind (with or without stripes), weigh 9-11 kg, and have red flesh (USDA, 1978). This group includes varieties named Sangria, Fiesta, and Regency. In the Ice-Box group are varieties such as Sugar Baby, Petite Sweet, and Yellow Doll (USDA, 1978). These melons are round, weigh 2.5-7 kg, can have either red or yellow pulp, and can have dark or light green rind (USDA, 1978) Varieties such as Crimson Trio, Farmers Wonderful and Honey Heart are seedless type of watermelons (USDA, 1978) Seedless watermelons weigh 4.5-11 kg, are oval to round in shape, have a light green rind with dark green stripes, and can have either red or yellow flesh. The melons in the “yellow-flesh” variety have yellow to bright orange flesh/pulp, are oblong to long in shape, weigh 4.5-14 kg, and have light green rind with blotchy stripes (USDA ,1978) Desert King, Orangeglo, and Tender Sweet are all yellow-flesh type watermelons (USDA ,1978. Wehners (2003), has also listed some popular varieties of watermelon in the world these are sweet princes, Crimson Sweet, improved shipper, jubilee, Charleston Gray, Charleston Sweet, Sugar Baby and Special White.

2.3 HEALTH BENEFITS OF WATERMELON

Watermelon has been associated with a number of health benefits. Studies have shown that lycopene has the potential of reducing the risk of cancer of the lungs, prostate, colon and stomach (Wills *et al.*, 1989). Additionally, the risk of developing heart attack and other cardiovascular diseases has been shown to be reduced by lycopene (Schulter *et al.*, 1990 possibly due to its high cholesterol reducing effects. Apart from lycopene, other beneficial phytochemicals and antioxidants such as, carotenoids, Vitamin C and beta-carotene has been indicated to be present in watermelon (Wehner and Maynard, 2004). Vitamin C for an example helps prevent infections and viruses, and also helps slow the aging process and development of

cataracts (USDA, 1978). In addition, vitamin C aids in strengthening blood vessels and bones as well as help repair damaged tissue and heal wounds (USDA, 1978). Vitamin C is also an essential nutrient for humans because it plays a crucial role in the synthesis of collagen in addition to protecting against oxidative damage. Vitamin C consumption has also been shown to protect against cancers of the mouth and lungs, improve cholesterol, and prevent scurvy (Vergano, 1991). Small amounts of potassium, which can help alleviate muscle cramps, along with miniscule amounts of calcium and iron are also found in watermelons (USDA, 1978).

2.4 QUALITY CHARACTERISTICS OF WATERMELON FRUIT

The term quality is best defined according to the end user. When used in respect to plant produce, quality often describes the characteristics; attributes and value (intrinsic and extrinsic) of a plant produce which makes it acceptable to the end user. The quality of the watermelon fruit therefore refers to all the factors or characteristics of the fruits that contribute to the consumer's acceptance of the commodity. According to William (1989), high quality watermelon fruits should have a good soluble solid content of ten percent or more in the flesh near the centre of the melon fruit. The United States (US) standard for grades of watermelon as observed by USDA (1979) revealed that watermelon fruit with 81% total soluble solid is considered as having good internal qualities. Consumers consider many factors before they demand for the watermelon fruits. These include sweetness, sugar content, moisture content, total acidity, fruit juice, absence of bruises, surface abrasions and cracks among others (USDA, 1978).

2.4.1 Total Soluble Solids Content (TSS)

The total soluble solids (TSS) content of the fruit flesh is an important property for quality. Total soluble solids is more often than not associated with the sweetness of the fruit and is sometimes used as one of the main quality parameters in determining maturity (Wills *et al.*, 1981; Tian *et al.*, 2007). The total soluble solid content of the melon fruit is mainly sucrose and fructose which is measured by a refractometer (Brix Equivalent). Generally, total soluble solid content of 8% is considered as marginal, 10% is acceptable and 12% or more means excellent. The Standards for determining maturity of watermelon is based on the level of soluble solids (Wills *et al.*, 1989). According to Maynard (2001), sweetness is one of the prime quality factors in watermelon fruit and it is related to total soluble solids. The total soluble solids of watermelon decreases during respiration and it is also broken during ripening.

Respiration is the oxidative breakdown of more complex materials such as starch, sugar and organic acids into simpler molecular carbon dioxide and water. Picha (1988) reported that the soluble solid content of watermelon varieties such as Crimson Sweet is 10.2° Brix and that of Florida Giant variety is 9.6° brix, which is due to the fact that these watermelons are usually grown during the rainy season. The total soluble solid content of the watermelon fruit together with the moisture content, sugar content are very important factors that must be considered when designing equipment for industries and postharvest technology such as maturity detectors and in improving the quality and processing characteristics in watermelon processing industry.

2.4.2 pH, Total Titratable Acids and Moisture content of Watermelon

The test that measures all the acids present in a given fruit is referred to as total titratable acids (TTA) whereas pH is a measure of the strength of these acids. The pH levels are used to

determine acidity in food. The pH level of 7 is considered to be neutral. Food substances with pH levels lower than 7 are acidic and food substances with pH level higher than 7 are basic or alkaline. The pH level depends on the fruit variety and the growing conditions such as the soil. The pH value of the watermelon fruit juice is considered as a sign of the fruit maturity (Wehner, 2003). At pH level of 9.0, watermelon becomes highly alkaline. According to William (1999), one way of examining field maturity of the watermelon fruits from the point of view of the pH level is to randomly harvest a few of the watermelons and testing their sugar to acid ratio using the digital refractometer. The pH of the fruit juice is extracted and measured, 10ml of the sampled juice extract is treated with 40ml distilled water, the electrodes is simply pushed into the sample and measured under stirring and when the physico-chemical composition of the watermelon drift value set on the titrator has been reached, the pH value is shown automatically. Watermelons have a comparable slightly acidic pH range of about 5.2 to 5.6 (FAO, 1989).

The pH level is one of the main criteria for assessing the safety of products. The acid in the juice helps to prevent the growth of bacteria which are dangerous. According to FAO (1989) watermelon that are unripe have higher pH value and at complete maturity stage the acid content decreases equally causing reduction in the pH level because the acid content of fruit juice is directly related to the pH level. (Salman *et al.*, 2008) reported that the acid content as well as the pH level of the fruit juice of watermelon do not usually increase any further after the produce is harvested from the parent plant. A related study by (Perins, 2001) revealed that watermelon fruits usually do not acquire a sour taste after harvest and during storage which implies that the total acidity and pH level of the fruits remains relatively stable at harvest. The pH value of the watermelon fruit juice remains fairly constant during senescence and it is related to spoilage of the fruit (Gortner *et al.*, 1967).

2.4.3 Moisture content of Watermelon

The moisture level of the watermelon is on the average of 92% (Hayes, 1987; USDA, 2003). Fresh harvested fruits and vegetables are mostly made up of water with most of them having 90-95% moisture content. Water lost after harvest is one of the most serious postharvest conditions consequently special efforts are required to reduce the effects of these naturally occurring processes if quality of harvested fruits in the field will be the same at the consumer level. The flesh crispness of the watermelon fruit is associated with high moisture content (Sergent, 2000). According to FAO (1989), respiration is a reaction of all plants both in the field and after harvest. Fresh produce continues to lose water after harvest and therefore the water content of the fruit at harvest must be used up. At complete maturity stage, the moisture content of the fruit is reduced and this affects the weight of the fruit. The loss of water in the fruit is due to loss of water vapour through the stem scars, stomata, and epidermis of the fruit. Maximization of water loss of the fruit can be achieved through the waxy layer of the outer layer surface of the fruit (Kays, 1991).

2.5 HARVEST AND POSTHARVEST HANDLING OF WATERMELON

Harvesting is the process of detaching the fruit from the main plant. During harvesting it is very important that appropriate precautionary measures are fully employed to ensure that fruits do not sustain cracks, scratches and other physical blemishes. Some of these measures include; harvesting fruit during the coldest time of the day to maintain low product respiration and prevent excessive loss of water through transpiration, wounding, bruising, crushing or damage from human and harvesting equipment should be avoided and the harvested produce should be kept in a cold storage facility as soon as possible. Postharvest handling practices are the practices that ensure that the integrity of the produce are not compromised from the time of harvesting to the time the produce gets to the final consumer (Levin *et al.*, 2001). Some of the

postharvest practices that are employed in watermelon production may include the following pre-cooling for rapid removal of heat to achieve effective quality preservation. According to (Picha, 1988), pre-cooling methods include room cooling, force-air cooling, water-cooling, vacuum cooling and packaging icing.

Injuries generally occur during transport with the interaction of the road and vehicle suspension system. The vibration caused during transport is semi-random occurring across a large range of frequencies and with jolts and bumps in the road adding to the background vibration (Hilton, 1994). The irregular nature of vibration input makes it difficult to define a threshold for vibration damage. Fruits would vibrate when the frequency of the vibration reaches a certain level if the resonance frequency of the fruit colour is the same as the excitation frequency of the vehicle or road. The acceleration of the fruit can be considerably increased due to the resonance and thus severe damage can result (Sitkel, 1986). In stacked or palletized produce, the vibration can be directed up through the stock and thus increasing in magnitude at the higher level (Sitkel, 1986). The main types of damage to fruits are bruising and tearing of skin (external and internal damage) (Monseni, 1987).

The modulus of elasticity is a very important mechanical property of fruit and its variation can be described as internal damage in transportation (Ogut *et al.*, 1999). The damage is always greatest on the top layer of the fruit and under severe transport condition; it may extend down one, two or three layers (O'Brien and Gullow, 1969). Watermelon requires extensive handling during harvest and market distribution and because of their weight and size, proper care is required during handling. Carelessness during transit results in surface abrasion and damaging impacts to the watermelon. Serious impacts will cause external and internal damage which is

characterized by cracks in the fleshy tissues that will be undetected until the watermelon is cut open.

2.6 POSTHARVEST LOSSES OF WATERMELON

Postharvest losses are losses that occur from the time of harvest to the time the produce gets to the final consumer. The types of postharvest losses that occurs in perishables and for that matter watermelon include; colour change, flavour change, physical damage, rot, insect and rodent pest attack and pathological disorders.

2.6.1 Colour and Flavour Changes

Watermelon has normal dark green colour and change in that colour can lead to the outright rejection of the watermelon by consumers and this represents a loss to the producer. (USDA, 1978). Stated that colour influences other sensory characteristics, which subsequently influences food acceptability, choice and preference. Colour of a product is unacceptable to a consumer, the flavour and texture may not be considered at all (USDA, 1978). Colour may also be used as an indicator to determine the types and quantities of various carotenoids. In watermelon the sugars and organic acid determines the taste of the fruit however, the complex interaction of sugars, organic acids, phenolics and more specialized flavour compounds such as alcohols, esters, aldehydes determine the flavour of fruits. If a watermelon fruit does not conform to the normal taste or for instance there is a reduction in sweetness, consumers will not buy such products (USDA, 1978).

2.6.2 Pathological Disorder

Pathological disorders in watermelon arise because of disease conditions. Affected fruits normally begin to rot sooner than their expected shelf life. Sometimes pathogens release

poisonous substances known as mycotoxin into fruits making them unsafe for consumption. A diseased fruit is sometimes unattractive and may appear abnormal however, it should also be noted that some diseased fruits might appear normal and look good until senescence sets in (Rushing, 2004)

2.6.3 Insect Pests of Watermelon

Watermelons are susceptible to several kinds of insect infestations. Aphids, cabbage loopers, cucumber beetles, cutworms, leafhoppers, thrips, leaf miners and spider mites are all known to infest watermelon crops. However, all can easily be treated with pesticides or by biological means. Organisms such as lady beetles and lacewings, as well as foods like bran and molasses, can be used as alternate tools to manage pests (Schulter *et al.*, 1990).

2.6.4 Physical Disorders of Watermelon

These damages predispose the fruit to microbial attack and hasten deterioration. Physical damage represents a qualitative loss because no one will buy watermelon with cuts or cracks. The rejection of such fruits with defects is a loss due to compromising of quality (Rushing, 2004). Physical damage in watermelon includes; mechanical injury, chilling injury, cracks, bruises, and abrasion

2.6.4.1 Mechanical injuries

Mechanical injuries on the fruit sustained during handling are the main reason for considerable decline of fresh fruits and vegetable production. Waste due to damage in the chain between growers and consumers is estimated to be around 30-40% (Peleg and Hinga, 1986). Rough handling during harvest, loading, and unloading of watermelons will result in fruit bruising, cracking, and high amounts of postharvest loss. Internal bruising leads to premature flesh

breakdown and mealiness. Watermelons should not be dropped, thrown, or walked on, as internal bruising and flesh breakdown will occur (USDA, 1978)

2.6.4.2 Skin abrasion

Watermelon requires extensive handling during harvesting, distribution and marketing due to its weight and size; proper care is required during handling. Carelessness during transit result in surface abrasion and damaging, mostly internal, impact abrasion, compression and vibration damaged based on the type of force acting on the fruit. Vibration damage occurs when fruits are subjected to vibratory type of stimulus which cause impact abrasion and compression injuries. Vibration may cause only one of these types of damage or all the three.

They are roughly handled during harvest, harvesting and unloading resulting in fruit bruising, surface abrasions, cracking and consequently high amount of postharvest loss (Rushing *et al.*, 2004). Improper handling and loading of bulk watermelons too often result in serious transit losses due to surface abrasion, bruising and cracking (Cartao *et al.*, 1997). According to Lallu *et al.* (1999), vibration of the watermelon fruit during transport generally result in melon surface abrasion of the skin with a smaller amount of compression damage and little impact injury vibration. Injuries generally do occur during transport with the interaction of the road and vehicle suspension system.

The vibration caused during transport is semi-random occurring across a large range of frequencies and with jolts and bumps in the road adding to the background vibration (Hilton, 1994). During transport, the stacked or palletized produce will vibrate which can be directed up through the stock and thus increasing in magnitudes resulting in damage to the fruits as surface abrasions, bruising and tearing of skin (external and internal) (Monseni, 19787).

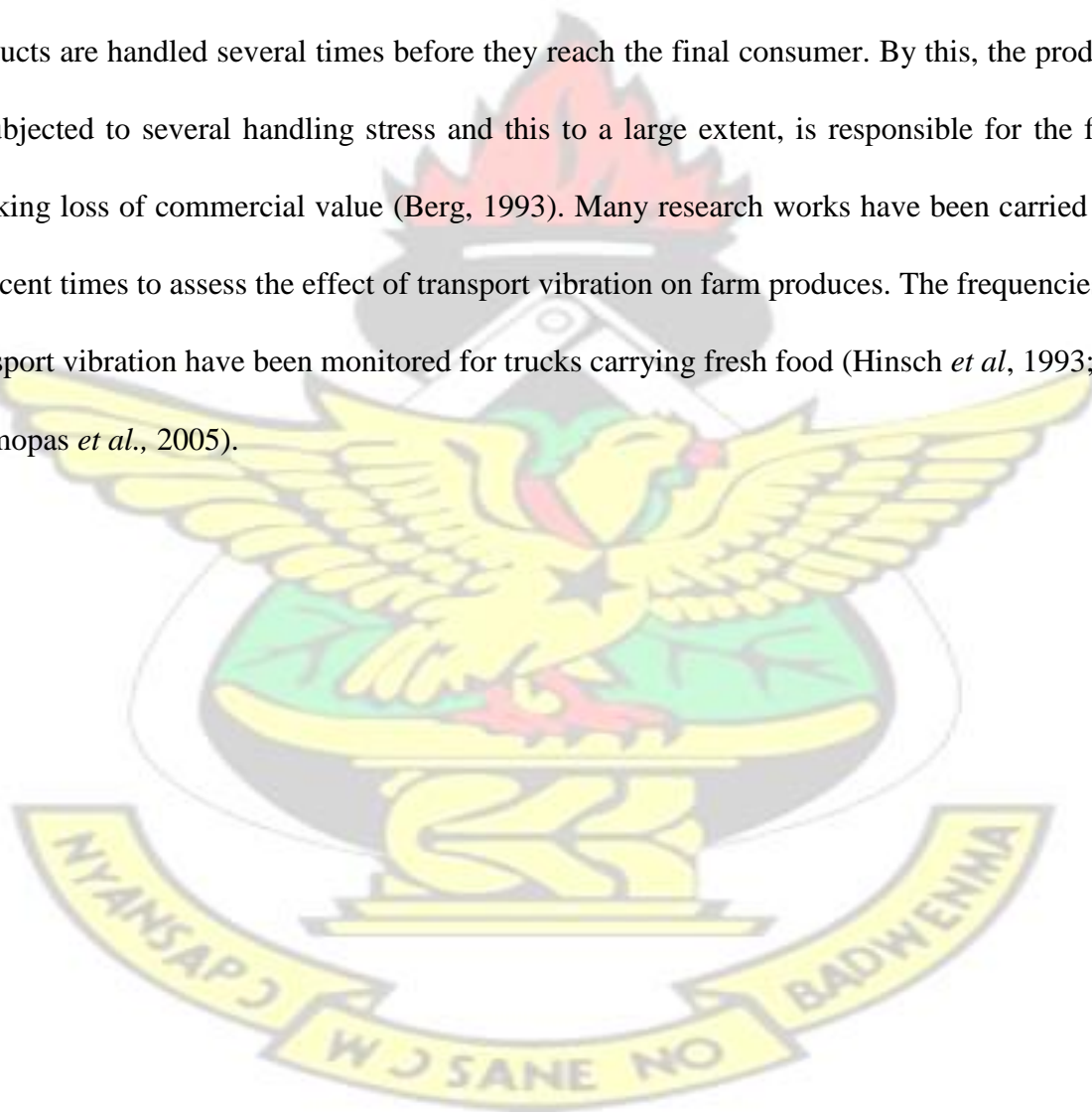
High quality watermelons are one of today's expectations by consumers. Locally produced watermelons are readily available seasonally and have resulted in consumers demanding some freshness and quality on seasonal basis. The price received for watermelon produce is determined by quality at the market place. Different consumers perceived as a reflection of produce quality which are ranked in order of preference as, Crispness, freshness, taste, appearance and condition nutritive value and price (Picha, 1988)

2.6.4.3 Watermelon fruit cracks

Excessive rough handling during harvest, loading and unloading of the watermelon fruits causes cracks. Rough handling such as dropping of fruit, throwing the fruit and the fruits being walked on largely account for fruit internal bruising and flesh break down. According to Armstrong *et al.* (1977), watermelon requires extensive handling because of its delicate nature during harvest and market distribution and because of their weight and size; proper care is required during handling. Carelessness during transit can result in watermelon surface abrasion and damage to the internal layer. The impacts to the melon when severe damage will cause obvious external damage but frequently also internal damage characterized by cracks in the flesh tissues that will be used until the watermelon fruit is cut open. During transportation on rough roads, damage to the watermelon fruit due to dropping vibration may not be seen in the outside of the fruit but will show up internally as water soaked areas that breaks down quickly (Martin, 1966).

Due to their large size and susceptibility to splitting or cracking under mechanical stress, watermelon fruits should not be harvested in the early morning when they are mostly turgid as the modulus of elasticity of the fruit is adversely affected when the fruit is turgid and easily

cracks (Azudin *et al.*, 1989). In Africa, generally, the movement of watermelon from the farm gates to market place is accomplished by vehicles. In Ghana, for instance, the bulk of the watermelon grown in the hinterlands is transported to the marketing centres in various types of opened top trucks of various capacities to the marketing centres in the urban areas. They are conveyed along rough and untarred roads with potholes mostly located thirty kilometers (30km) to the marketing centres where they are off loaded and distributed to other markets. The products are handled several times before they reach the final consumer. By this, the produce is subjected to several handling stress and this to a large extent, is responsible for the fruit cracking loss of commercial value (Berg, 1993). Many research works have been carried out in recent times to assess the effect of transport vibration on farm produces. The frequencies of transport vibration have been monitored for trucks carrying fresh food (Hinsch *et al.*, 1993; Jarimopas *et al.*, 2005).



CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The study area comprised communities namely; Savulugu, Kumbungu and Nyankpala, all in the Tamale Metropolis. These communities were chosen because they contribute immensely to the quantity of watermelon marketed in the Tamale Metropolis and also transported to other regions in Ghana.

3.2 RESEARCH DESIGN

To avoid bias and to improve the validity and reliability of the study, the simple random sampling technique was employed to select 50 watermelon traders for interview. The study was conducted in two parts; a field survey and laboratory work

3.2.1 Field Survey

Primary data was derived by interviewing 50 watermelon traders through structured questionnaires administration and personal observations. The secondary data was sourced from institutions such as MOFA, Savannah Agriculture Research Institute (SARI) and the Association of Watermelon Traders in the Metropolis, the Universities in addition to consultation of relevant journals, dissertations and other publications.

3.2.2 Questionnaire Design and Administration

Open and close type questions were used in conducting the study as seen in the appendices. It was categorized into various sections focusing on the socio-demographic features, challenges faced by respondent during storage and transportation of watermelon and the quantity

purchased. The questionnaires also sought information on source of produce, road condition, distance to source of supply and mode of transportation. Prior to the questionnaire administration, a focus group discussion was undertaken to explain the purpose of the study and the questionnaire to them.

3.3 SAMPLING OF WATERMELON FRUITS

The watermelon fruits were harvested by the farmers and assembled in heaps under sheds for a day to remove field heat prior to transport to the marketing centres. The watermelon samples were selected from these heaps. The varieties used for the experiment included Charleston Gray, Crimson Sweet and Sugar Baby. The watermelon fruits averagely weighed 3kg for all the three varieties. Moisture content, total titratable acidity, total soluble solids, pH, bruises and cracks were parameters studied on the three (3) watermelon varieties before transporting to the marketing centres.

3.4 MODE OF TRANSPORTATION

The modes of transport used in this experiment were;

- Mini pick-up truck (unroofed at the top) – 250 watermelon fruits
- Kia mini truck (unroofed at the top)- 150 watermelon fruits
- Motoring tricycle (roofed at the top) – 100 watermelon fruits
- Kia mini truck (unroofed top) – 300 watermelon fruits

Each vehicle was loaded with each variety of watermelon fruits to its normal capacity and conveyed across the study area within a distance of (15 km) with the same type of road conditions to the Tamale central market in the Northern Region of Ghana.

3.5 EXPERIMENTAL DESIGN

The experimental design was laid in a 3x4 factorial in a completely randomized design (CRD) with four (4) treatments and each was replicated three times.

3.6 LABORATORY WORK

Samples of water melon fruits were randomly selected from each of the treatment, labeled and carefully packaged into paper cartons cases. The packing cases were sealed off at the top and stored at room of average temperature of 28° C and relative humidity of 80% for a day. The fruits were then transported to the Crop and Soil Science laboratory at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana for chemical analysis.

3.7 DETERMINATION OF SOME QUALITY CHARACTERISTICS

3.7.1 Moisture Content

Two (2) grams weight of the fruit was taken, placed in a crucible and dried in an oven for 24 hours (Hayes, 1987) at a temperature of 65°C. The weight of the dried sample was then taken and subtracted from the initial weight. The percentage moisture was calculated by the formula:

$$\text{Percentage moisture content} = \frac{W_{ht0} - W_{ht1}}{W_{ht0}} \times 100$$

3.7.2 Mechanical Damage

Water melon fruits from each treatment were assessed for the presence of bruises and cracks. The value was expressed in percentage of the total number of fruit in each mode of transportation.

3.7.3 Total Soluble Solids (TSS)

This was determined by the use of digital refractometer (Reed MT-032 Brix Refractometer, Taiwan) and the value reported as Degree Brix (Gortner *et al.*, 1967).

3.7.4 Total Titratable Acidity (TTA)

In measurement of the TTA, 10ml of juice from the various samples were titrated with 0.1M NaOH and the result expressed in percentage citric acid (Jarimopas, 20005)

3.7.5 pH

pH of the fruit juice was measured using pH meter. Thirty grams (30g) weight of each fruit added to 90ml of distilled water was blended in a laboratory for two minutes and filtered. The pH electrode, washed in distilled, water was placed in the filtrate for a few minutes to allow the reading to be stable and the pH value recorded for all the cultivars (Gortner *et al*, 1967; Hayes, 1987).

3.8 DATA ANALYSIS

Data collected from the field survey was analyzed using SPSS statistical software version 13 (USA) and the results were expressed as percentages while the laboratory results were analyzed using Student edition of Statistix 9 statistical package.

CHAPTER FOUR

4.0 RESULTS

4.1 FIELD SURVEY

4.1.1 Demographic Information of Water melon traders

From the survey Table 4.1, it was observed that majority (96%) of the watermelon traders were females while 4% were males. Most of the traders (40%) were between the ages of 30-39 years while those in the age range of 40-49 years were 34%. Twenty percent (20%) of the traders were above fifty (50) years while 6% of them were in the age range of 20-29 years.

In terms of educational background, majority (76%) of the watermelon traders had no formal education. Fourteen percent (14%) of them had primary school education with 10% having Senior High School/Junior High School or middle school level. According to working experience, 38% had been in the trade for 1-3 years, 20% had been in the business for 4-6 years while 42% of the traders had been in the watermelon trade for more than 7 years.

Table 4.1: Demographic Information of Traders

VARIABLE	Frequency	Percentage %
Gender		
Male	2	4
Female	48	96
Totals	50	100
Age of respondents		
20-29	3	6
30-39	20	40
40-49	17	34
50 and above	10	20

Totals	50	100
---------------	-----------	------------

Educational Background

Primary	7	14
SHS/JHS/Middle form 4	5	10
No formal education	38	76
Totals	50	100

Number of years in Watermelon Business

1-3 Years	19	38
4-6 Years	10	20
More than 7 Years	21	42
Totals	50	100

4.1.2: Marketing Characteristics and Problems Encountered during Transportation of water melon

Table 4.2 shows that majority (60%) of the water melon traders obtained their fruits at the farm gate while 24% and 16% sourced from wholesalers and retailers respectively. With regards to the knowledge of varieties of watermelon, 90% of the traders had no information on the variety traded in while 10% of them had knowledge of the varieties of watermelon sold. Majority (92%) of the water melon traders sorted their produce before packaging for transportation. However, 8% of the traders did not sort their produce. The two major problem faced by the water melon traders were lack of storage facilities (25.70%) and mechanical damages (74.30%) such as cracks (26.90%) and bruises (73.10%).

Most (96%) of the roads used by the traders were untarred whilst 4% of the roads were tarred.

It was observed that 3 modes of transportation mostly used by the respondents were the Kia

truck (26 %), Kia truck mini (34%) and tricycle/ motor king (40%). The distance to the source of supply was 5-10 km (20%), 10- 20 km (64%) and more than 20km (16%).

KNUST



Table 4.2 Traders Marketing Characteristics and Problems Encountered

Source of watermelon	Frequency	Percentage (%)
Farm gate	30	60
Wholesalers	12	24
Retailers	8	16
Totals	50	100

Awareness of watermelon varieties		
Yes	5	10
No	45	90
Totals	50	100

Sorting of produce		
Yes	46	92
No	4	8
Totals	50	100

Major problems faced after transportation		
Storage facility	9	18
Mechanical problem	26	52
None of the above	15	30
Totals	50	100

Mechanical problem		
Cracks	7	14
Bruises	19	38
None of the above	24	48
Totals	50	100

Road condition		
Tarred	2	4
Untarred	48	96
Totals	50	100

Mode of transportation		
-------------------------------	--	--

Kia truck	17	26
Kia truck mini	13	34
Tricycle/motor king	20	40
Totals	50	100

Distance to source of supply		
5-10 km	10	20
10-20 km	32	64
More than 20 km	8	16
Totals	50	100

4.2 LABORATORY ANALYSIS

4.2.1 Chemical composition and physical qualities of water melon before transportation

Crimson Sweet variety recorded the highest moisture content of (95.00%) which was significantly different ($p < 0.01$) from the others. Charleston variety recorded significantly higher (92.33%) moisture content while Sugar Baby variety had the least moisture content (9.00%).

From the study, no significant differences ($p > 0.01$) were recorded for total titratable acidity among the varieties studied. Sugar Baby, Crimson Sweet and Charleston varieties recorded 0.24%, 0.17% and 0.13% of TTA, respectively.

For the highest total soluble solids content of the watermelon, Sugar Baby variety recorded significantly 9.42% followed by Crimson Sweet (8.56%) variety with Charleston variety recording the least (8.03%).

pH for the water melon varieties varied between 5.07% and 5.23%. Significant differences ($p < 0.01$) were observed among the varieties. Sugar Baby variety recorded the highest (5.23%) pH content followed by Crimson Sweet (5.30%) variety while Charleston variety recorded the

lowest.

Regarding mechanical cracks on the water melon, Crimson Sweet variety had the highest bruises (4.33%) and was significantly different ($p < 0.01$) from Charleston and Sugar Baby varieties which had bruises of 2.66% and 2.00%, respectively. Crimson Sweet recorded the highest cracks of 2.33% which was significantly different from Charleston (1.66%) variety and Sugar Baby variety (1.00%).

Table 4.3: Chemical composition and physical qualities of watermelon before transportation

Water Melon Varieties	Moisture Content	Total Titratable Acidity	Total Soluble Solids	pH	Bruises	Cracks
Crimson Sweet	95.00a	0.17a	8.56ab	5.30a	4.33a	2.333a
Charleston	92.33b	0.13a	8.03b	5.07b	2.66b	1.66ab
Sugar Baby	91.00b	0.24a	9.24a	5.23a	2.00b	1.00b
LSD	1.76	0.14	0.71		0.94	0.94
CV	0.95	38.70	4.15	1.45	15.71	28.28

4.2.2 Effect of transportation on chemical composition and physical qualities of water melon varieties

Table 4.4 indicates that significant differences ($p < 0.01$) were recorded for moisture content among the varieties after transportations. Crimson Sweet variety recorded the highest moisture content of 95.42% followed by Charleston (92.00%) and Sugar Baby (92.00%) varieties respectively.

No significant differences ($p>0.01$) were recorded among the three varieties for total titratable acidity. Crimson Sweet variety had 0.23% of TTA while both Charleston and Sugar Baby varieties recorded 0.19% each.

Total Soluble solids for the three varieties ranged between 7.81% and 8.35%. Total soluble solids for Sugar Baby (8.35%) were significantly higher than both Charleston (7.86%) and Crimson Sweet (7.81%).

For pH, Crimson Sweet recorded the highest (5.22%) and was significantly different from Sugar Baby (5.06%) and Charleston (5.14%).

There were no significant differences ($p<0.01$) among the varieties for both bruises and cracks. Crimson Sweet variety recorded 20.33% of bruises, Sugar Baby variety recorded 18.58% of bruises while Charleston variety recorded 18.08% of bruises. For cracks after transportation, Crimson Sweet, Charleston and Sugar Baby varieties had 6.00%, 5.92% and 5.58% respectively.

Table 4.4: Effects of transportation on chemical composition and physical qualities of water melon varieties

Water Melon Varieties	Moisture Content	Total Titratable Acidity	Total Soluble Solids	pH	Bruises	Cracks
Crimson Sweet	95.42a	0.23a	7.81b	5.22a	20.33a	6.00a
Charleston	92.00b	0.19a	7.86b	5.06b	18.08a	5.92a
Sugar Baby	90.66c	0.19a	8.35a	5.14ab	18.58a	5.58a

LSD	1.18	0.08	0.46	0.11	3.23	0.88
CV	1.52	47.97	6.91	2.70	20.19	18.07

4.2.3 Effect of different mode of transportation on chemical composition and physical qualities after transportation

From Table 4.5, fruits conveyed by Kia mini truck recorded moisture content of 93.00% followed by motor Kia tricycle (92.88%), Kia-mini truck unroofed (92.11%) and then Mini Pick up unroofed (92.11%). However, no significant differences ($p>0.01$) were recorded among them.

For total titratable acidity (TTA), no significant difference ($p>0.01$) was recorded among the transportation modes. Motor Kia tricycle recorded total titratable acidity of 0.23%, Kia mini truck unroofed and mini pick-up truck unroofed recorded 0.20% each and a value of 0.18% was recorded for the Kia mini truck (unroofed).

Fruits conveyed by Kia mini truck (roofed top) had significantly the highest total soluble solids (8.40%) but there were no significant differences ($p>0.01$) among the motor Kia tricycle, Kia mini truck and mini pick-up truck which recorded 7.83%, 7.90% and 7.90% respectively.

Fruits in Kia mini truck recorded the highest pH value of 5.22% and were significantly different from fruits conveyed in Kia mini truck unroofed which recorded the lowest pH of (5.06%). The other two; motor Kia tricycle and the mini pick up which showed no significant difference ($p>0.01$) between them recorded 5.08% and 5.19% of pH respectively.

After transportation, fruits conveyed by the Kia motor tricycle had the highest bruises of 22.33% which was significantly different ($p < 0.01$) from the Kia mini truck (16.88%) and the mini pick up that recorded the lowest value of (16.66%). Bruises value of (20.11%) was recorded for Kia mini truck unroofed which showed no significant difference ($p > 0.01$) among the rest.

Cracks found among the four modes of transportation ranged from 4.00% to 7.44%. Fruits conveyed by Motor Kia tricycle recorded 7.44% of cracks which was not significantly different ($p > 0.01$) from mini-pick up (7.33%). However, fruits conveyed by Kia mini truck unroofed which recorded crack value of 4.55% was significantly different from roofed top type which recorded 4.00%.

Table 4.5: Effect of different modes of transportation on chemical composition and physical qualities after transportation

Mode of Transportation	Moisture Content	Total Titratable Acidity	Total Soluble Solids	pH	Bruises	Cracks
Kia Mini Truck (roofed top)	93.00a	0.20a	8.40a	5.22a	16.88b	4.00b
Motor Kia Tricycle	92.88a	0.23a	7.83b	5.08ab	22.33a	7.44a
Kia-Mini Truck (unroofed)	92.77a	0.18a	7.90ab	5.06b	20.11ab	4.55b
Mini-Pick-Up Truck(unroofed)	92.11a	0.20a	7.90ab	5.19ab	16.66b	7.33a
LSD	1.36	0.09	0.53	0.13	3.73	1.02
CV	1.52	47.97	6.91	2.70	20.19	18.07

4.2.4 Interactive effect of transportation and varieties on chemical composition and physical qualities of water melon.

4.2.4.1 Moisture content

From Table 4.6, the highest moisture content (96.00%) was recorded when Crimson Sweet variety was transported by both Kia motor tricycle and mini pick-up truck unroofed and was significantly different ($p < 0.01$) from the other means of the transportation. Sugar Baby variety transported by Kia mini pick-up unroofed recorded the lowest moisture content (90.00%) which was not significantly different ($p > 0.01$) from the others except for crimson sweet variety in Kia mini truck roofed top (95.66%), Crimson Sweet variety in Kia motor tricycle (96.00%), Crimson Sweet variety in Kia mini truck- unroofed top (94.00%), Crimson Sweet variety in mini pick-up truck (96.00%) and Charleston variety in Kia mini truck roofed top (93.33%).

4.2.4.2 Total soluble solids

For effect of varieties and mode of transportation on total soluble solids of water melon (Table 4.7), it was observed that Crimson Sweet variety transported in Kia mini truck unroofed top recorded the highest total soluble solids of 8.56% followed by Sugar Baby variety in motor tricycle (8.50%), Sugar Baby variety in Kia mini truck unroofed (8.20%), Sugar Baby variety in mini pick up (8.20%), Crimson Sweet variety in Kia mini truck- unroofed (8.06%) and Charleston variety in motor tricycle (8.03%). However, no significant difference ($p > 0.01$) was recorded among them except for crimson sweet variety in Kia motor tricycle which had significantly the lowest total soluble solids (6.96%).

4.2.4.3 pH

The result of the study (Table 4.7) showed that Crimson Sweet variety transported in Kia minitruck recorded pH of 5.43% which was not significantly different from the same variety transported in motor Kia tricycle (5.20%) and mini pick-up truck unroofed (5.20%) as well as Sugar Baby variety transported in mini pick up unroofed (5.30%). However, these treatments were significantly different ($p < 0.01$) from the rest of the interactions. Charleston variety transported in Kia mini truck roofed top also recorded the lowest pH (5.00%) and showed no significant difference ($p > 0.01$) with the others except Crimson Sweet variety transported in Kia mini truck (roofed top), motor Kia tricycle, mini pickup (unroofed top) and Sugar Baby variety transported in mini pickup truck unroofed.

4.2.4.4 Bruises

Kia motor tricycle used to conveyed Crimson Sweet variety 25.66% of bruises followed by Crimson Sweet variety conveyed with Kia mini truck unroofed (21.33%) and motor Kia tricycle used to conveyed both Charleston (21.00%) and sugar baby (20.33%) varieties showed no significant differences ($p > 0.01$) occurring among them. The least bruises were recorded when Charleston variety was conveyed with mini pickup truck unroofed (15.66%), Charleston variety in Kia mini truck (16.00%), Crimson Sweet variety in Kia mini truck-roofed top (17.00%) and Sugar Baby variety in mini pickup truck (17.00%). No significant differences ($p > 0.01$) were, however, recorded among these ones.

4.2.4.5 Cracks

After the varieties have been transported from the farm, the highest (8.00%) cracks were found in Charleston variety transported with Kia motor tricycle which was significantly different

($p < 0.01$) from the lowest (3.66%) which was recorded in Sugar Baby variety transported in Kia mini truck (unroofed).

Table 4.6: Interactive effect of transportation and varieties on some chemical composition and physical qualities

Source	Moisture Content	Total Soluble Solids	pH	Bruises	Cracks
Kia Mini truck roofed top) X Crimson Sweet	95.66ab	8.56ab	5.43a	17.00b	5.66bc
Motor Kia Tricycle X Crimson Sweet	96.00a	6.966d	5.20abc	25.66a	7.00ab
Kia mini truck (unroofed) X Crimson Sweet	94.00abc	8.06abc	5.066bc	21.33ab	4.00cd
Mini Pick-Up truck(unroofed)X Crimson Sweet	96.00a	7.633cd	5.20abc	17.33b	7.33ab
Kia Mini truck roofed top) X Sugar Baby	91.00de	8.50abc	5.06bc	20.33ab	7.33ab
Motor Kia Tricycle X Sugar Baby	90.66e	8.50abc	5.06bc	20.33ab	7.33ab
Kia Mini truck unroofed top) X Sugar Baby	91.00de	8.20abc	5.16bc	19.33ab	3.66d
Mini Pick-Up truck (unroofed) X Sugar Baby	90.00e	8.20abc	5.30ab	17.00b	7.33ab
Kia Mini truck (roofed top) X Charleston	93.33bcd	7.66bcd	5.00c	16.00b	4.33cd
Motor kia Tricycle X Charleston	92.00cde	8.03abc	5.06bc	21.00ab	8.00a
Kia mini truck (unroofed) X Charleston	92.33cde	7.90abc	5.10bc	19.66ab	7.33ab
Mini Pick -Up truck (unroofed top) X Charleston	90.33e		5.09bc	15.66b	4.00cd
LSD	2.36	<u>7.86abcd</u> 0.93	0.23	6.46	1.77

CHAPTER FIVE**5.0 DISCUSSION****5.1 DEMOGRAPHIC INFORMATION OF THE WATERMELON TRADERS**

In Ghana, gender plays a vital role in the agricultural sector, men engaged in cultivation of crops while women do activities such as harvesting and marketing. From the study, the high female population (96%) in the watermelon business confirms many reports that women dominate in the marketing of agricultural commodities and hence greater number of women involvement in trading of watermelon. The greater percent of the people aged between 30 -39 years involved in the trading of watermelon indicated that most of the youth have now developed interest in the marketing of agricultural produces and thus their involvement in marketing of watermelon. The results also indicated that majority (76%) of the farmers had no formal education which confirms the low level of education in the Northern Region. These findings are contrary to Jeffery (1975) who found majority of dealers in the water melon business to have completed middle school in the Ada East District of Ghana. It was observed that all the traders had some level of experience in the watermelon business with majority of them having experience between 4 to more than 7 years.

5.2 MARKETING CHARACTERISTICS OF WATER MELON TRADERS

Majority (60%) of the watermelon traders interviewed obtained their produce from the farm gate while the rest were sourced from either wholesalers or retailers. These findings may be due to cheaper prices of the water melon at farm gate compared to the prices of the water melon when it gets to the market for sale. It was also found that majority (90%) of the traders were

not aware of the various varieties of water melon they were trading in. This may be as a result of the high illiteracy level of the traders as majority (76%) of them had no formal education.

Sorting of the water melon before buying were also investigated and it came out that majority (92%) of the traders do sorting of the produce to get rid of defects or disease ones before buying them. This finding was expected since most of the respondents were somewhat experienced traders who had been engaged in the water melons trade for more than 7 years. Thus, they knew the effect of what not sorting can do to the produce.

5.3 CHALLENGES ENCOUNTERED DURING TRANSPORTATION OF THE WATER MELON FRUITS

Water melons were mostly transported from the farm gate to the various destinations through the use of Tricycle (motor king), Kia mini trucks and mini pick up. From the study, it was observed that the use of Tricycle (Moto king) was the major (40%) means of transportation used by the watermelon traders. This may be attributed to affordability and the availability of this means of transport in the Tamale metropolis compared to the other transports. From the study, the two major problems faced by the traders during transportation were storage facility and mechanical problems with the mechanical problems (bruises and cracks) being prevalent.

Bruises (73.1%) were the main mechanical problems found on water melon fruits during transportation. This might be due to the poor state of different modes of transportation and the poor nature of the roads (untarred with pot holes) that impede the smooth movement of the various modes of transportation used in conveying the watermelon fruits. Poor nature of agriculture roads negatively affects transportation of agriculture commodities in many part of the country particularly perishable commodities like watermelons. Almost 64% of the traders

conveyed their produce to a distance of 10-20 km on untarred rough road with potholes before reaching their customers. According to Levin *et al* (2001b) bruises and cracks are among the principal causes of the losses of water melon as it occurs during loading, transportation and off-loading operations.

5.4 POSTHARVEST HANDLING PRACTICES

During field observations, it was identified that, there were two main postharvest handling practices used by the water melon traders. These were pre-cooling and sorting.

5.4.2 Pre-cooling

Fruits, after harvesting, were heaped under a shed and covered with old jute sacks and straws. The purpose of pre-cooling was for rapid removal of field heat to achieve effective preservation and storage. Heat accumulated in the water melon leads to faster deterioration of the fruits

5.4.3 Sorting

Watermelon fruits were sorted at the farm gate by traders by visual means (use of eyes) and sensory means (palm-feeling). This was done to remove diseased and other defected fruits before they are transported to market centers. Failure to sort other diseased and defected fruits from the wholesome ones led to faster deterioration of the wholesome ones. This also affected the quality of the watermelon fruits. It was, therefore, encouraging that all producers were involved in this activity

5.5 CHEMICAL AND PHYSICAL QUALITIES BEFORE TRANSPORTATION

5.5.1 Moisture Content

The moisture content of the three varieties ranged from 91.00% – 95.00%. According to USDA (2003), water melon should have an average moisture content of about 92% and the moisture content of the varieties under study was within range. However, the moisture content in Crimson Sweet variety transported in both motor king and mini-pickup were higher (96%). Water lost after harvest is one of the most serious postharvest conditions that can affect the final quality of the water melon. From the results, moisture content of the Crimson Sweet variety was the highest (95.00%) while that of the Sugar Baby was the lowest (91.00%). The highest moisture content in Crimson Sweet variety suggested it had flesh crispness than sugar baby and Charleston varieties. According to Sargent (2000), flesh crispness of the watermelon fruit is associated with high moisture content. This suggests that the Sugar Baby variety would lose water easily compared to the other varieties and hence will also lose its freshness faster. This is due to the fact that, fresh produce continue to lose water after harvest and therefore the water content of the fruit at harvest are used up.

The perishable nature of water melon informs the kind of purchasing system practiced by farmers leading to little or no loss on the farm. This also explains why watermelon is mostly eaten fresh after harvest or processed into juice by the processing industries.

5.5.2 Total Soluble Solids

Total Soluble Solids (TSS) is mostly used as a criterion for determining the level of maturity and quality in fruits such as melons, citrus and grapes (Martin, 1996). The total soluble solid content of the melon fruit is mainly sucrose and fructose. Significant differences were only

observed between Charleston (7.86%) and Sugar Baby (8.35%) variety. The TSS content of the varieties after transporting them in the three different kinds of transport also ranged between 6.96% and 8.56%. Generally, total soluble solid content of 8% is considered as marginal, 10% is acceptable and 12% or more means excellent. That is the total soluble solids contents of the treatments were of marginal quality.

The Standards for determining maturity of watermelon is also based on the level of soluble solids (Wills *et al.*, 1989. According to Monseni *et al.* (1978), fruit harvested at the matured green stage had the lowest total soluble solids content and ascorbic acid level. However, fruit harvested at light red stage had the highest TSS content. Thus, the amount of soluble solid in the fruit was known to increase with maturation (Ndorom *et al.*, 2001). These changes could be attributed to the conversion of starch to sugar during ripening. The results also suggest that the farmers harvested the water melon at the right matured stage.

Sweetness is one of the prime quality factors in watermelon fruit and it is related to total soluble solids (Maynard, 2001). The total soluble solids of watermelon decreases during respiration and it is also broken during ripening. The lowest total soluble solids observed in this study may be due to the fact that they had just been freshly harvested and the high total soluble solid contents may probably be due to its low total titratable acidity (Table 4.3). From the results, it was observed that Sugar Baby variety had the highest TSS (9.24%) which indicates it was sweeter than the other varieties, a reflection of the name of the variety.

5.5.3 Total Titratable Acidity

Total titratable acidity (TTA) measures all the acids available in the fruit. The acidity of the water melon varieties under this study was low. The low acidity might be as a result of the high

total soluble solids of the fruits and this corroborates a report from O'Brien and Gullow (1969) who stated that titratable acidity of fruits decreases as ripening occurs.

During ripening, there is decrease in organic acids in most fruits and may be a reason why the fruits were tastier. However, the low acid content implied that the fruits would be prone to spoilage organisms and deteriorate faster when stored for a longer time.

5.5.4 pH

pH is a measure of the amount of hydrogen and hydroxyl ions in the solution of the fruits juice and indicates its acidity. The pH content of varieties after transporting in the three different modes of transportation ranged between 5.00 and 5.43 compared to the pH contents of the varieties before transportation which were between 5.07 to 5.30. There was not much change in the pH level of the fruits after transporting and this might be attributable to the fact that the acid content as well as the pH level of the fruit juice of watermelon do not usually increase any further after the produce is harvested from the parent plant (Salman *et al.*, 2008). Decline in acidity during ripening is as a result of degradation of acids into soluble sugars thus reducing the acidity of the fruit leading to an increase in pH values as the fruit ripens (Ogut *et al.*, 1999). According to Olorunda and Tung (1985), most fruit pH averages ranges between 4.3 and 4.4. Water melon juice pH is also known to vary with growth, location, harvest time, fruit maturity and other similar factors which affect the fruit (Pantastico, 1975) and these might be reasons for the differences in the pH of the varieties under study.

5.5.5 Bruises

According to Pearson, (1976) the main types of damage to fruits are bruising and tearing of skin (external and internal damage). From the results, percentage bruises on varieties were 2.00% to 4.33% before transportation. Bruises on water melon fruits after transporting them by the three different modes of transport ranged between 15.66% and 25.66% with Crimson Sweet variety transported in motor king tricycle recording the highest (25.66%). This indicates an increase in the bruises percentage during transportation which might also be attributed to the poor conditions of the vehicles used for transporting the water melon fruits. The untarred roads as well as handling methods used in packing the fruits into the vehicles might be reasons for the increase in the bruises on the fruits. Watermelon requires extensive handling during harvest and market distribution and because of their weight and size, proper care is required during handling. Carelessness during transit results in surface abrasion and damaging impacts to the watermelon and also creates room for infections which affects the quality of the fruit.

5.5.6 Cracks

Cracks recorded on water melon varieties before transporting were between 1.00% and 2.33% while cracks in water melon varieties after transport ranged between 3.66% and 8.00%. An increase was observed in the level of cracks on the water melon varieties after transport and this could be as a result of vibrations caused during transport. Poor handling of fruits during harvest, loading and unloading of the watermelon fruits also causes cracks. Poor handling such as dropping of fruit, throwing of fruits during packaging and the fruits being walked on largely account for fruit internal bruising and cracks (Peleg, 1985). Poor handling of fruits during transit can result surface abrasion and damage to the internal layer.

The different varieties reacted differently to the mode transportation might be due to the poor nature of rural roads, poor loading of the fruits, and bad nature of the respective modes of transportation, particularly the level of weak shock absorbers of the modes of transportation.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

A study was conducted to determine the effects of different mode of transportation on the quality of watermelon fruits in Tamale, Northern Region of Ghana. From the survey, females dominated in the water melon business with majority of them aged between 30-39 years. Most of the producers of water melon fruits had no formal education but had experience between 4 and more than 7 years. Water melon traders sourced their produce from the farm gate but were not aware of the varieties of water melon they sold. The two most important post handling practices carried out by producers of water melon were pre-cooling and sorting. Pre cooling of produce immediately after harvest was done to remove field heat while sorting of the produce was done to get rid of diseased and unwholesome fruits in order to prolong the shelf-life of the fruits. The major means of transportation of water melon fruits in the Tamale Metropolis was the use of Tricycle (Motor king). Two major problems faced by the traders of water melon were mechanical problems (bruises and cracks) and storage facilities.

Chemical and physical composition of the water melon fruits before and after transportation were also studied. Moisture content of the varieties ranged from 91.00-96.00% with Crimson Sweet variety transported in both motor king and mini-pickup recording the highest. The total soluble solids of the water melon fruits ranged between 6.96% and 8.56% and were considered

to be of marginal quality. The acidity of the fruits was low with their pH content ranging between 5.00% and 5.43% after and before transporting the fruits.

Bruises and cracks were the two main mechanical problems that affected the water melon fruits during transportation. Percentage bruises on water melon varieties were 2.00% to 4.33% before transportation but increased to between 15.66% and 25.66% after transporting them to the market. Cracks recorded on the water melon varieties before transport were between 1.00% and 2.33% while cracks in water melon varieties after transport ranged between 3.66% and 8.00%.

The type of vehicle used to transport the water melon fruits to the market had a negative effect on the chemical and physical qualities of the water melon fruits, especially the Crimson Sweet variety. The shelf-life of the produce was reduced and cannot be stored for a longer time after transportation.

6.2 RECOMMENDATION

The Kia mini truck with roofed top and pick up with roofed top were the most efficient means for the transportation of watermelon fruits. Due to the poor nature of farm roads and the use of Tricycle (motor King) being the major mode of transport, it is therefore recommended that Tricycle should be lined with cushions and the top roofed to minimize mechanical injuries due to dropping of fruits, rubbing of the surfaces with each other and direct impact of heat from the sun.

REFERENCES

AOAC, Association of Official Analytical Chemist (1990). Official methods of Analytical Chemist 15th edition, Arlington VA. pp. 257-299

Armstrong P. R. Stone M. L and Brusewl Z.G.H. (1977). Nondestructive Acoustic and Compressive measurements of Watermelon for Internal Damage Detection APP/Eng.Agric .13(5); 641-645 Avgi.s.1969 melon. Ministry of Agriculture and Natural Resources, Cyprus pp.2007-2010

Azudin. M. N., Augustine, M. A., Azizah, O. and Suchail, M. (1989). Postharvest Physiology of Malayan Fruit. In: D N Maynard (ed) watermelons Characteristics production and marketing Astts press Alexandria. v. a pp. 27-73.

Berg T. (1993).The Science of plant Breeding –support or alternative to Traditional practices. Fn .Boof W.SK. pp 541- 565

Bisognin D.D 2002. Origin and evolution of cultivated Cucurbits, Ciencia Rural, Santa Maria 32 (5). 715-723

Cartao, C.B, Sargent, S.A and Huber, D. J. (1997). Controlled atmosphere storage suppresses microbial growth on fresh-cut watermelon production. Fla. State Hort. Soc.110:252-257.

FAO (Food and Agriculture Organization) 1989. Prevention of postharvest food losses,

Fruits, Vegetables and Root Crops, a training manual, <http://www.Fao.org/docrep/Too73E/Too73.Evz.htm> #4.7% Respiration (Retried on 8/07/2013). 334 yau. E.W. Rosnah. Norgzuah, M. chin .N.L. and Osman, International Food Research Journal 17:327-334.

FAOSTAT (2008). Crops, FAOSTAT Food and Agricultural Organization of the United Nations (Database) <http://Faaostat.fao.org/site/567/default.aspx#ancor>.

Goreta, S., Perica S., Dumicic G., Bucan, L. and Zank, K. (2005). Growth and yield of watermelon on polyethylene mulch with different spacing and nitrogen rates J. American Society Horticulture Science. 40 (2); 366-369

Gortner .W.A.; .Dull, G. G. And Krayss, B.H (1967). Fruit development, maturation, ripening and senescence. A biochemical basis for horticultural terminology Hort. science 2(4)

Guner, N and WehnerT. C. (2004).The Genes of Watermelon .American Journal of Horticulture Science .39 (6), 1175-1185

Hayes, G. D. (1987). Food Engineering Data Handbook. Longman scientific and Technical US

Hilton, D.J (1994).Impact and Vibration Damage to fruits during Handling and Transportation ACIAR Proc. Postharvest Handling of Tropical Fruits).50:116-126

Hinsch, R.T.; Slaughter D.C.; Craig, W.L. and Thomson, J. F. (1993). Vibration of fresh

Fruits and Vegetables during Refrigerated truck transport Trans. ASAE 36:1039-1042

Huh, Y.C.; Solmaz, I. and Sari, N. (2008). Morphological Characterization of Korean and Turkish watermelon germplasm. Cucurbitaceae. Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae (Pitrat, M. ed) INRA Avignon (France), May 21st - 24th 2008

Ikeorgu, V.E. G. (1991). Effects of maize and cassava on the performance of intercropped egushu melon (*Citrullus Lanatus* (L) Thunb) and okro (*Abelmoschusecullentus* (L) Moench). In Nigeria Scientia Horticulture 48:261-268

Jarimopas, B.; Sing H. S. P. and Saengil, W. (2005). Measurements and Analysis of Truck Transport Vibration level and Damage to packaged Tangerines during transit. Package Technol. Sci. 18; 179-188

Jeffery, C. (2007). Cucurbitaceae. In: Hanelt. (ed) Mansfield Berlin, Germany, pp 1510-1557

Jeffery, C. (2001). Cucurbitaceae. In: Hanelt (ed) Mansfield ornamentals Vol3 Springer. Berlin Germany. Pp.1510-1557

Jeffery, C. (1975). Further notes on cucurbitaceae. Some African taxa Kew Bul; 30:475-493

Jensen, B. D. (2012). African watermelon in sari N. Solmaz I Aras. V editors' cucurbitaceae 2012 proceedings of the 10th Eucarpia meeting on Genetics and Breeding of cucurbitaceae.

Adana. Cukurova University 2012:264-274

Kays, S.J. (1991). Postharvest physiology of perishable plant products. AVI publishing Co. New York.pp157-187

Lallu, N.; Rose, K.; Wiklund, C. and Burdon J. (1999). Vibration Induced Physical Damage in packed Hay ward Kiwifruit Acta Hort.498; 307-312

Levin, A.C.; Thomas, E.; Wehner, T. C. and Zhang, X. (2001). Low Genetic Diversity Indicates the need to broaden the Genetic Base of cultivated watermelon. Journal of American Horticultural Science .36(6) 1096-1101.

Loukou, A.; Gnakri, L.; Djey, D.; Kippre, A. V.; Malice, M.; and Baudoin, J. B. (2000). Macronutrients composition of three cucurbit species cultivated for seed consumption in Cote d, voire Afri. J. Biotechnnnnol.6.529-533

Maggs–Kolling, G.; Madsen, S. and Christiansen, J. K. (2000). Aphenetik analysis of morphological variation in *Citrullus lanatus* in Namibia, Genet. Resource crop. Evol-47:388393.

Martin, C. (1996). Quality Assurance for Melons perishable handling Newsletter, issue. No. 85

Matanyaire, C. M. (1998). Sustainability of pearl millet (*Pennisetum gaucucm*) productivity in northern Namibia current situation and challenges South Africa Journal of Science.94'157166

Maynard, D.N (2001). In Uses and Nutritional Composition <http://watermelons.ifas.edu/uses> and Nutritional-Composition htm. Retrieved on 8/0702013.

Monseni, N.N. (1978). Physical properties of food and Agricultural materials 2nd Revised and updated Edition Gordon and Breach Science Publishers. New York 18

Mujaju, C.; Johanson, E. and. Labuschange, M. (2012). Genetic diversity of community practices to its conservation on farm in Sarin, Solmaz. E. Aras, V. editors cucurbitaceae 2012 proceedings of the 10thEucarpia meeting on Genetics and Breeding of Cucurbitaceae. Adana,Cukurova University 2012 p-374-377.

Ndorom F.; Madakadze, R. M. and Kagelersmashingaze, A. B. (2001). Indigenous Knowledge of the traditional vegetable Pumkin (*cucurbita maximua/moschata*) from Zimbabwe. Afr.j.Agr.Res.2:647-655.

O' Brien, M. and Gullow, R. (1969). An intransit Vibration Simulator for Fruit Handling Studies Trans. Asae-12;94-97

Ogut, H.; Peker. A. and Ayudin, C. (1999). Simulated Transit Studies on peaches. Effects of container cushion materials and Vibration on Elasticity modules. Agricultural Mechanization in Asia, Africa and Latin America; 30: 59-62

Olorunda, A. O and Tung M. A (1985). Simulated Transit studies on Tomatoes Effects of compressive Load Container Damaged J, Food Techno, 20:669-678

Pantastico E. R. B. (1975). Postharvest physiology, Handling and Utilization of Tropical and Sub Tropical Fruits and Vegetables. The AVI Publishing Company INC

Pearson, D. (1976). The Chemical Analysis of Food 6th Edition Longman Group Limited London

Peleg, K. (1985). Produce –handling, packaging and distribution. Department of Agriculture Engineering Techno, Israel Institute of Technology, Haifa, Israel. The Avi Publishing Company –INC

Peleg. K. and Hinga. S (1986). Simulation of vibration Damage Introduce Transportation Transa. A.S.A.E 29(2) 633-641

Perins –Veazie, P.; Collins, J. K.; Pair, S.D. and Robert, S.W (2001). Zycopene Content differs among red fleshed Watermelon Cultivars. J. Science Food Agric -81:983-987

Picha, D.H. (1988). Storage temperature influences watermelon quality. Lousiana Agriculture 31: 4-5

Robertson, H. (2004). *Citrullus lanatus* watermelon (Tsamma), Museums on line South Africa, Iziko Museums of Cape Town on line publication: [htt:// museum.org.za/bio/index.htm](http://museum.org.za/bio/index.htm)

Robinson, R.W and Decker-Walter D.S (1997). Cucurbits.C AB International USA.

Rubatzky V.R and Yamaguchi. M (1997). World Vegetables. Principles, production and nutritive values.2nd ed. Chapman and hall, New York.

Rushing J.W (2004).In color Atlas of postharvest; Quality of fruit and Vegetable (Nunesmariacecilliado Nascimendoeds) pp: 2007-209, Black well publishing

Salman-minkov, A. and Trebitsh. T. (2008). Characterization of watermelon fruits development <https://w3.Avignon.nra.fr/dspce/bitstream/2174/283/1/60-66-salman.pdf>,
(Retrieved on 4/4/2014)

Sargent. S. A (2000). Handling Florida Vegetables, Watermelon, University of Florida. Departmental of Horticultural Sciences. Florids Cooperative Extension Service Institute of Food and Agriculture Science publication ss-VEV-934 <http://edu.ifas.ufl.edu/pdffiles/VH/vit009400.pdf> (accesses; postharvest physico-mechanical properties of orange peel and fruit. Journal of Food Engineering 73:112-120

Schulter –Pason, N. L.; Timm, E. J.; Brown, G. K.; Mashall, D. E. and Burton, C. (1990). Apple Damage Assessment during Interstates Transportation Appl. Eng. Agric 6:753-758

Silwana, T. T. and Lucas, E. O. (2002). The effect of planting combination and weeding on the growth and yield of component crops of maize and beans and maize and pumpkin intercrops Agriculture science 138: 193-200

Sitkei, G. (1986). Mechanics of Agricultural materials Elsevier. Amsterdam pp .122 -167

Slaughter, D.C.; Hirsch R.T. and Thompson, J.F (1993). Assessment of vibration injury to Bartlett pears Trans. ASAE, 36! 1043-1047

Tindal H. D (1983). Vegetables in the Tropics. The Macmillan Press Limited London pp.150152

USDA (US Department of Agriculture) (1978). A US standard, for grades of watermelons [http:// watermelon.if.ufl.edu/uses](http://watermelon.if.ufl.edu/uses) and Nutritional Composition htm ((Retrieved on 27/3 /2014)

USDA (US Department of Agriculture) (2003). Nutritional Composition of watermelon.<http://watermelon.ifas.ufl.edu/Uses> and Nutritional Composition htm (Retrieved on 27/3/2014).

USDA (US Department of Agriculture) (1979). US Standards for grades of watermelons. [http://watermelon. ifas.uf/.edu/uses](http://watermelon.ifas.uf.edu/uses) and Nutritional Composition (Retrieved on 27/3/2014)

Vergano, P. J.; Testin, R. E and Newall, W.C (1991). Peach bruising susceptibility to impact vibration and consumption abuse. Transactions of the ASAE 34(5) 2110-2116

Wehner, T.C and Maynard D. N. (2004). Cucumbers, melons and other cucurbits in S.H Katz (ed). Encyclopedia of food and Culture Scribner and sons New York p. 2014

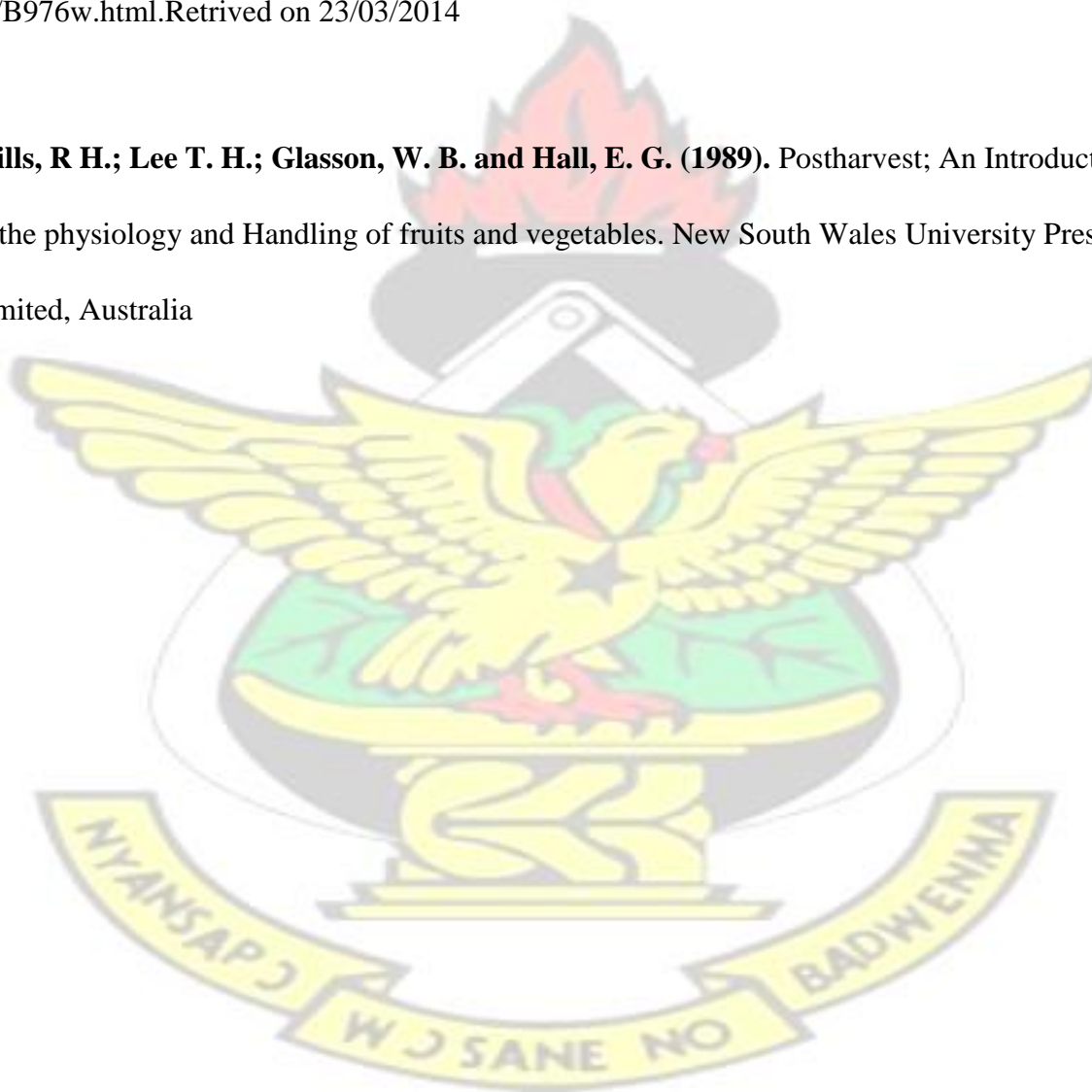
Wehner, T.C. and Maynard, D. N. (2003). Cucumbers melons and other cucurbits In. S.N.

Katz (ed) Encyclopedia of food and culture Scribner and Sons New York p.2014

Wehner, T. C.; Shetty N. V. and Elmstron G.W. (2001). Breeding and seed productionpp.177-189

William C. H (1999). The University of Georgia College of Agricultural and Environmental Science Cooperation Extension Service. http://pubs.Caes,uga.edu/Caes_pubs/pubca/B976w.html.Retrived on 23/03/2014

Wills, R H.; Lee T. H.; Glasson, W. B. and Hall, E. G. (1989). Postharvest; An Introduction to the physiology and Handling of fruits and vegetables. New South Wales University Press Limited, Australia



APPENDICES

APPENDICE A: ANOVA TABLES OF SOME CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES AFTER TRANSPORTATION

Student Edition of Statistix 9.0

2/28/2015, 12:11:44 PM

Analysis of Variance Table for MC

Source	DF	SS	MS	F	P
Transport	3	4.306	1.4352	0.73	0.5455
varieties	2	144.056	72.0278	36.52	0.0000
Transport*varieties	6	19.944	3.3241	1.69	0.1678
Error	24	47.333	1.9722		
Total	35	215.639			
Grand Mean	92.694	CV	1.52		

Analysis of Variance Table for PH

Source	DF	SS	MS	F	P
Transport	3	0.16226	0.05409	2.80	0.0619
varieties	2	0.15369	0.07684	3.97	0.0323
Transport*varieties	6	0.19484	0.03247	1.68	0.1695
Error	24	0.46427	0.01934		
Total	35	0.97506			
Grand Mean	5.1439	CV	2.70		

Analysis of Variance Table for TSS

Source	DF	SS	MS	F	P
Transport	3	1.8675	0.62250	2.03	0.1365
varieties	2	2.1217	1.06083	3.46	0.0479
Transport*varieties	6	3.4983	0.58306	1.90	0.1219
Error	24	7.3600	0.30667		
Total	35	14.8475			
Grand Mean 8.0083		CV 6.91			

Analysis of Variance Table for TTA

Source	DF	SS	MS	F	P
Transport	3	0.01000	0.00333	0.34	0.7946
varieties	2	0.01389	0.00694	0.71	0.4997
Transport*varieties	6	0.04167	0.00694	0.71	0.6417
Error	24	0.23333	0.00972		
Total	35	0.29889			
Grand Mean 0.2056		CV 47.97			

Student Edition of Statistix 9.0 3/2/2015, 4:09:22 PM

Analysis of Variance Table for brusises

Source	DF	SS	MS	F	P
varieties	2	33.500	16.7500	1.14	0.3372
Transport	3	200.222	66.7407	4.53	0.0118
varieties*Transport	6	32.944	5.4907	0.37	0.8889
Error	24	353.333	14.7222		
Total	35	620.000			
Grand Mean 19.000		CV 20.19			

Analysis of Variance Table for cracks

Source	DF	SS	MS	F	P
varieties	2	1.167	0.5833	0.53	0.5982
Transport	3	88.556	29.5185	26.57	0.0000
varieties*Transport	6	6.611	1.1019	0.99	0.4531
Error	24	26.667	1.1111		
Total	35	123.000			

Grand Mean 5.8333 CV 18.07

APPENDICE B: ANOVA TABLES OF SOME CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES BEFORE TRANSPORTATION

Student Edition of Statistix 9.0

2/28/2015, 9:57:28 AM

Completely Randomized AOV for MC

Source	DF	SS	MS	F	P
varieties	2	24.8889	12.4444	16.00	0.0039
Error	6	4.6667	0.7778		
Total	8	29.5556			

Grand Mean 92.778 CV 0.95

Homogeneity of Variances F P

Levene's Test	0.84	0.4761
O'Brien's Test	0.37	0.7028
Brown and Forsythe Test	0.33	0.7290

Welch's Test for Mean Differences

Source	DF	F	P
--------	----	---	---

varieties	2.0	10.85	0.0283
-----------	-----	-------	--------

Error	3.7		
-------	-----	--	--

Component of variance for between groups 3.88889

Effective cell size 3.0

varieties Mean

charleston 92.333

crimsonsw 95.000

sugar baby 91.000

Observations per Mean 3

Standard Error of a Mean 0.5092

Std Error (Diff of 2 Means) 0.7201

Completely Randomized AOV for PH

Source	DF	SS	MS	F	P
varieties	2	0.08402	0.04201	7.40	0.0240

Error	6	0.03407	0.00568		
-------	---	---------	---------	--	--

Total	8	0.11809			
-------	---	---------	--	--	--

Grand Mean 5.2011 CV 1.45

Homogeneity of Variances F P

Levene's Test 1.35 0.3279

O'Brien's Test 0.60 0.5786

Brown and Forsythe Test 0.31 0.7427

Welch's Test for Mean Differences

Source	DF	F	P
--------	----	---	---

varieties	2.0	7.11	0.0510
-----------	-----	------	--------

Error	3.9		
-------	-----	--	--

Component of variance for between groups 0.01211

Effective cell size	3.0
---------------------	-----

varieties	Mean
-----------	------

charleston	5.0700
------------	--------

crimsonsw	5.3000
-----------	--------

sugar baby	5.2333
------------	--------

Observations per Mean	3
-----------------------	---

Standard Error of a Mean	0.0435
--------------------------	--------

Std Error (Diff of 2 Means)	0.0615
-----------------------------	--------

Completely Randomized AOV for TSS

Source	DF	SS	MS	F	P
--------	----	----	----	---	---

varieties	2	2.20740	1.10370	8.64	0.0171
-----------	---	---------	---------	------	--------

Error	6	0.76660	0.12777	Total	
-------	---	---------	---------	-------	--

8	2.97400				
---	---------	--	--	--	--

Grand Mean	8.6100	CV	4.15
------------	--------	----	------

Homogeneity of Variances

	F	P
--	---	---

Levene's Test	2.26	0.1851
---------------	------	--------

O'Brien's Test	1.01	0.4199
----------------	------	--------

Brown and Forsythe Test	0.68	0.5431	Welch's Test for Mean Differences
-------------------------	------	--------	--

Source	DF	F	P
varieties	2.0	15.35	0.0216

Error 3.3

Component of variance for between groups 0.32531

Effective cell size 3.0

KNUST

varieties Mean

charleston 8.0300

crimsonsw 8.5600

sugar baby 9.2400

Observations per Mean 3

Standard Error of a Mean 0.2064

Std Error (Diff of 2 Means) 0.2919

Completely Randomized AOV for TTA

Source	DF	SS	MS	F	P
varieties	2	0.01860	0.00930	1.85	0.2370

Error 6 0.03020 0.00503

Total 8 0.04880

Grand Mean 0.1833 CV 38.70

Homogeneity of Variances F P

Levene's Test 1.80 0.2448

O'Brien's Test 0.80 0.4928

Brown and Forsythe Test 0.15 0.8656

Welch's Test for Mean Differences

Source	DF	F	P
varieties	2.0	1.23	0.3891
Error	3.8		
Component of variance for between groups			0.00142
Effective cell size		3.0	

varieties Mean

charleston	0.1333
crimsonsw	0.1733
sugar baby	0.2433

Observations per Mean	3
Standard Error of a Mean	0.0410
Std Error (Diff of 2 Means)	0.0579

Completely Randomized AOV for bruises

Source	DF	SS	MS	F	P
varieties	2	8.6667	4.33333	19.50	0.0024
Error	6	1.3333	0.22222		
Total	8	10.0000			
Grand Mean	3.0000	CV	15.71		

Homogeneity of Variances F P

Levene's Test	2.00	0.2160
O'Brien's Test	0.89	0.4591
Brown and Forsythe Test	0.50	0.6297

Welch's Test for Mean Differences

Source	DF	F	P
varieties	2.0	M	0.0000
Error	M		
Component of variance for between groups		1.37037	
Effective cell size		3.0	

varieties Mean

charleston 2.6667

crimsonsw 4.3333

sugar baby 2.0000

Observations per Mean 3

Standard Error of a Mean 0.2722

Std Error (Diff of 2 Means) 0.3849

Completely Randomized AOV for cracks

Source	DF	SS	MS	F	P
varieties	2	2.66667	1.33333	6.00	0.0370
Error	6	1.33333	0.22222		
Total	8	4.00000			
Grand Mean		1.6667	CV 28.28		

Homogeneity of Variances F P

Levene's Test 2.00 0.2160

O'Brien's Test 0.89 0.4591

Brown and Forsythe Test 0.50 0.6297

Welch's Test for Mean Differences

Source	DF	F	P
varieties	2.0	M	0.0000
Error	M		
Component of variance for between groups		0.37037	
Effective cell size		3.0	

varieties Mean

charleston 1.6667

crimsonsw 2.3333

sugar baby 1.0000

Observations per Mean 3

Standard Error of a Mean 0.2722

Std Error (Diff of 2 Means) 0.3849

