The Use of Different Modes of Transportation Affects the Chemical Qualities of Watermelon Fruits (Citrullus lanatus [Thunb]) Transported from the Farm Gates in the Hinterlands to the Urban Markets in the Tamale Metropolis in the Northern Region of Ghana

Yakubu Victor.A.[1], Yakubu Jacob Fuseini[2], Musah Nimatu. H[3]
1. Tamale College of Education Box 1 ER, Tamale Ghana
2. Bagabaga College of Education Box 35 Tamale Ghana
3. Tamale College of Education Box 1 E/R, Tamale Ghana
*atmoang2010@yahoo.com

Abstract
The perishable nature of fruits and vegetables are a major concern to post harvest scientist. Postharvest handling practices particularly, mode of transportation is contributing to loss of essential chemical qualities of watermelon fruits. This study sought to identify the means of transport responsible for chemical damage in watermelons and also to assess watermelon varieties affected by these modes of transport in the Tamale Metropolis in Ghana. It revealed that watermelon conveyed by Kia Mini Truck (0.80 t) mode of transportation experienced the highest chemical damages (13.82 %) while watermelon conveyed by Mini Pick-up Truck recorded the least chemical damage (13.3%). It also showed that Sugar baby variety encountered the highest chemical damages (13.82%) while Crimson sweet variety recorded the lowest value (13.2 %)
Keywords: Chemical qualities, Total tartritable acidity, Total soluble solids, and moisture
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Introduction

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*). In West Africa, the use of watermelon seeds as a source of food has been reported (Loukou *et al., 2000*), when they are ripe, the sweet juicy pulp is eaten fresh and the rind is sometimes preserved (Dupree *et al., 1953*). The seeds are roasted as snack or grind into an ingredient in oils or sauces (Spivey, 1960).

In terms of the nutritional status, it 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.

Watermelon is also 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 (Giovannucci, 1999). Additionally, the risk of developing heart attack and other cardiovascular diseases has been shown to be reduced by lycopene (Fuhrman *et al., 1997*; Kohlmeier *et al., 1997*) 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 (Erhardt *et al., 2003*). Vitamin C for example helps prevent infections and viruses, and also helps slow the aging process and development of cataracts (National Watermelon Promotion Board, 2003).

In addition, vitamin C aids in strengthening blood vessels and bones as well as help repair damaged tissue and heal wounds (National Watermelon Promotion Board, 2003).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 (Fontham *et al., 1988;* Block, 1991; Ness *et al., 1996).* Small amounts of potassium, which can help alleviate muscle cramps, along with miniscule amounts of calcium and iron are also found in watermelons (National Watermelon Promotion Board, 2003).

Watermelon has become one of the fruits eaten by many Ghanaian households yet its production system in the country is challenged by several constraints which include: incidence of pests and diseases; drought, low soil fertility and inadequate inputs. Also, the means of transport used to convey the harvested watermelon fruits from the farm gates (production centres) to the marketing centres is another constraint. The means of transport used to conveying these produce is generally in open trucks or inside un-refrigerated vans. These means of transports are not ideal for maintaining fruit quality. The fruits on top of the load in open trucks are usually subjected to sun burns with fruits loaded inside enclosed vans subjected to overheating especially if transportation occurs during a hot sunny days and those fruits underneath the load are subjected to weight and vibration impacts from some nature of road shocks.

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 quality compromise (Ofosu-Anim, 2009).

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 and 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., 1998*) and peaches (Vergano e*t al., 1992)* are susceptible to vibration injury which appears as bruising, moisture loss and skin abrasion.

Excessive rough handling during harvest, loading and unloading of the watermelon fruits causes cracks. Rough handling such as dropping of fruit, throwing the fruits and 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 (Hartsfield *et al.,* 1972b). In Africa, generally, the movement of watermelon from the farm gates to market centres 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 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 (Singh and xu, 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; Jarimpas *et al*., 2005).

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 Williams (1999), 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).

The total soluble solids (TSS) content of the fruit flesh is an important property for quality. Total soluble solids is most 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., 1981). 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. Pincha (1988) reported that the soluble solid content of watermelon varieties such as crimson sweet is 10.2º Brix and that of Florida Giant variety is 9.6º 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 post-harvest technology such as maturity detectors and in improving the quality and processing characteristics in watermelon processing industry.

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 level is 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 (Avgi Soteriabu, 1969). At pH level of 9.0, watermelon becomes highly alkaline. According to Williams (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 physic-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 (Azudin et al., 1989) 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 (Gartner et al. 1967).

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 continue 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 lose 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).

The cultivation of watermelon is done in the hinterlands and transported to the urban markets and the means of transportation used affect the quality of watermelons. The high consumer demand for high quality fruits and vegetables in recent times has been a major debate. Even though watermelons are widely produced in Ghana, it production is constrained by inappropriate means of transport resulting in physical and chemical damages encountered during transportation of the harvested watermelon fruits from production centres to the marketing centres. The means of transportation used affects the quality of watermelon as they are transported within an average distance of 10-15 kilometers. These means of transport used to convey the produce are generally in open trucks or inside un-refrigerated vans which is not ideal for maintaining fruit quality. The fruits on top of the load in open trucks are usually subjected to sun burns while fruits loaded inside enclosed vans are subjected to overheating especially if transportation occurs during hot days. It is against this background that these studies sort to:

1. Identify the mode of transportation that is responsible for high mechanical damage to watermelon fruits during transportation from farm gates to the urban centres in the Tamale Metropolis.
2. Assess which watermelon varieties cultivated in the growing areas encounter high chemical damage as a result of the mode of transport used in conveying the fruits to the Tamale Metropolis.

Research questions

1. Which modes of transportation are responsible for high chemical damages in watermelon fruits transported from the growing areas to the marketing centres in the Tamale Metropolis.?
2. Which watermelon varieties cultivated in the growing areas encounter high chemical damage as a result of the mode of transport used in conveying the fruits to the Tamale Metropolis?

Materials and Methods

The study considered Kumbungu and Nyankpala communities in the Tamale Metropolis in Northern Ghana. These communities were selected because they are known communities associated with watermelon production. 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. That is three watermelon varieties against four different means of transport. The researcher visited the watermelon producing areas where harvested watermelon fruits were assembled in heaps according to the varieties. Sorting and selection was done to select fruits that had no physical blemish. Each watermelon fruit sampled averagely weighed 3kg were randomly selected before transpiration from each of the treatment, labeled and carefully packaged into paper packing cases. The packing cases were sealed off at the top and stored at room temperature of +28^{o} C; -80-R H and transported to the Science laboratory of the University for Development Studies Tamale, Ghana for chemical analysis of Moisture Content, Total Soluble Solids (TSS), Total Titratable Acidity (TTA) and pH.

The rest were then loaded into the various capacities of the means of transports of Tricycle (0.45 t), Kia mini truck (0.80 t) Mini pick-up truck (1 t) and Kia mini truck (1.5 t) and conveyed across the study area within an average distance of (10 -15 km) to the urban marketing centres in Tamale Metropolis. On arrival, the loaded watermelon fruits were offloaded and samples of the various varieties were again selected from each treatment of the various means of transport and subjected to laboratory analysis of Moisture Content, Total Soluble Solids (TSS), Total Titratable Acidity (TTA) and pH. The laboratory results were analyzed using Student edition of Statistics 9 statistical package.

Results and Discussion

Research question 1: Which mode of transportation is responsible for high chemical damages in watermelon fruits transported from the growing areas to the marketing centres in the Tamale Metropolis?

The data examined here included the modes of transportation responsible for high chemical damages in watermelon fruits transported within the study area. The results are presented in Table 1.

Table1. Chemical compositions of watermelon fruits before and after transportation using different modes of transportation

Mode of transportation		Moisture Content %		TTA %		TSS %		pH %	
		Before	After	Before	After	Before	After	Before	After
KIA mini truck	(0.80 t)	93.00	93.00	0.16	0.20	8.30	8.40	5.18	5.22
Tricycle	(0.45 t)	92.88	92.88	0.15	0.23	7.73	7.83	5.04	5.08
KIA mini truck	(1.5 t)	92.77	92.77	0.18	0.18	7.80	7.90	5.01	5.06
Mini pick-up truck	(1.00 t)	92.11	92.11	0.16	0.21	7.65	7.80	5.16	5.19

Source: Laboratory data, November 2015

Key: TTA (Total Titratable Acidity) TSS (Total Soluble Solids)

As can be observed from the table, Kia Mini truck (0.80 t) maintained the highest percentages (93.00%) of moisture content while Mini pick-up truck (1.00 t) recorded the least percentage (92.11 %) after transportation. This may be probably due to the exocarp (thick rind) of the fruit that controls moisture loss from the fruit surface.

This is not in consonant with (Rayan and Lipton, 1972; Showalter, 1973; Watada et al., 1987) that postharvest fruit quality rapidly decreases due to water loss.

In the case of total titratable acidity, Tricycle recorded the highest (0.23%) and Kia mini truck (1.50 t) had the least (0.18 %). While Kia mini truck indicated a maintained percentage (0.18%) before and after transportation, there was an increase in the other three modes of transportation KIA mini truck (0.80 t) (0.16% - 0.20 %) KIA mini truck (1.50 t) (0.15% - 0.23 %) Mini pick-up truck (1.00 t) (% 0.16 - 0.21 %) however, the increase was insignificant. This is in consonant with (Isaac *et al*., 2016) that postharvest quality status and shelf life of the fruits in part, will depend on some postharvest handling practices and treatments carried out after harvest.

Also, the table showed that the percentage of total soluble solids for all the four modes of transportation increased before and after transportation, however, the increase was insignificant. For example KIA mini truck (0.80 t) (8.30 % - 8.40 %) and Mini pick-up truck (1.00 t) (7.65% - 7.80%).This is in consistent with 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.

Despite the fact that there is a general increase in the percentages before and after transportation among the four modes of transportation, which was insignificant, KIA mini truck (0.80 t) recorded the highest (5.22 %) while KIA mini truck (1.5 t) recorded the lowest value (5.06 %)

Research question 2: Which watermelon varieties cultivated in the growing areas encountered high chemical damage as a result of the mode of transport used in conveying the fruits to the Tamale Metropolis?

The survey also investigated cultivated watermelon varieties that experience high mechanical damage during transportation. The results are presented in Table 2.

Table 2.2 Chemical composition of varieties of watermelon before and after transportation

Watermelon variety	Moisture content		TTA%		TSS %		pH %	
	Before	After	before	After	Before	After	Before	After
Crimson sweet	92.02	92.01	0.17	0.23	8.56	8.81	5.30	5.22
Charleston	92.03	92.03	0.13	0.19	8.03	8.86	5.07	5.06
Sugar Baby	92.01	92.00	0.19	0.24	8.24	8.35	5.23	5.14

Source: Laboratory data, November 2015
Key: TTA (Total Titratable Acidity) TSS (Total Soluble Solids)

Form the table moisture content decreased in percentage for all the three varieties of watermelon; Crimson sweet, Charleston Grey and Sugar Baby after transportation. However, the change is insignificant for example Sugar Baby (92.01%- 92.00 %). This agrees with (Hayes, 1987; USDA, 2003) who reported that 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.

With regards to total titratable acidity the highest percentage was recorded by Sugar Baby (0.24 %) while the least percentage was recorded by Charleston Grey variety (0.19%). It also reveals that; even though, there is a general increase in the percentages among the three varieties after transportation, the increase was insignificant for example Crimson sweet recorded (0.17% - 0.23%). This could be due to the influence of the environment within the study area. This is in agreement with Harshata Pal et al (2007) work on the effect of blending, additives and storage conditions on the quality of watermelon nectar reported that total titratable acidity of the watermelon nectars decreased throughout the period of storage.

With regards to total soluble solids, even though, values before and after transportation among the watermelon varieties was insignificant, Charleston Grey variety recorded the highest value (8.86%) while Crimson sweet recorded the lowest (8.81%). This is inconsistent with what Maynard (2001) reported that, "sweetness", one of the prime quality factors in watermelon fruit is related to total soluble solids (TSS). During storage period, the total soluble solid content of red seedless watermelon was decreased significantly due to the respiration process of the fruit. For pH, despite the fact that there was a general decrease in pH percentage values among the three varieties before and after transportation which is insignificant, Crimson sweet variety recorded the highest (5.22 %) while Charleston Grey variety recorded the lowest value (5.06 %)

Conclusion and recommendations

The study showed that watermelon conveyed by Kia Mini Truck (0.80 t) mode of transportation experienced the highest chemical damages (13.82 %) while watermelon conveyed by Mini Pick-up Truck recorded the least chemical damage (13.3%) It also revealed that Sugar baby variety of watermelon encountered the highest chemical damages (13.82%) while Crimson sweet variety recorded the lowest chemical damage (13.2 %).

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