



Effects of Harvesting Methods on the Quality Characteristics of Citrus Fruits in the Central Region of Ghana

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Abstract: Fresh citrus fruits play a significant role in human nutrition but its quality is affected by a lot of factors between the periods of harvest and consumption. Poor harvesting directly affects market quality and nutritive value of the fruits. For this reason, this study aimed at investigating the effects of harvesting methods on the citrus fruit quality characteristics in the Abura-Asebu Kwamankese and Mfantseman Districts in the Central Region of Ghana. The study was a descriptive survey using questionnaire for data collection. A sample size of 140 were involved in this study which consisted of 50 citrus farmers, 50 wholesalers of citrus and 40 consumers of citrus. The respondents were randomly selected from the two Districts. The findings from the study revealed that most farmers use hooks in harvesting the fruits, followed by hand picking and hand shaking of the branches. It was revealed that the harvesting methods have significant effects on the quality of the fruit. It also found out that fruit juice and rind are affected when poor harvesting methods are used. However, the findings from this study could not substantiate whether poor harvesting methods affect the sugar level of the fruits since the respondents were uncertain about it. From the findings, it was therefore recommended that farmers should start embracing mechanical harvesting and special treatments should be applied before, during or after harvesting the fruits.

Keywords: Citrus, Quality, Harvesting Methods, Hand-Picking, Hook Method and Shaking

1. Introduction

1.1. Background of the Study

Citrus are classified as the most widely cultivated fruit crops and rank first in the world fruits production [1]. The production of citrus has been grown enormously during the last four decades of the twentieth century reaching almost 9 million ha of growing areas and a production of about 130 million tons in 2011 and it is cultivated in more than 50 countries worldwide.

According to [2] the main producing countries are China, Brazil, USA, and Mexico. Due to its climatic suitability, the major producing countries are located in the tropical and subtropical regions, with the Mediterranean region ranking

around 20% of the world citrus production [3]. According to FAOSTAT, oranges constitute the bulk of the citrus fruit production, accounting for approximately 60% of global citrus production, followed by lemons and limes group with a total production of about 12% [1]. The remaining 28% consists of grapefruit, tangerines, mandarins, Clementines and Satsumas.

Citrus fruits or their products are being part of the daily human intake in one or the other forms all over the world hence are recognized as important components in human health. The growing of citrus is not only a source of income to the growers but also has some socio-economic importance in the life of the people. It has great opportunity for employment, provides raw materials to the citrus based industry and having nutritive, medicinal values and source of

prosperity [4].

With high demand and popular dietary preference, citrus fruit is widely consumed and has become an inseparable part of our diets. Recent developments in horticultural utilization and improved analytical technology have helped establish the analysis of citrus fruit chemical constituents. According to Keerthi, citrus fruits are characterised by their distinctive flavour. Citrus fruits are a good source of carbohydrates, dietary fibre, B vitamins, minerals, and biologically active phytochemicals such as carotenoids and flavonoids, which provide provitamin A activity and purported antioxidant benefits, respectively [5]. Such nutrient density, the low-fat, low-sodium profiles, and associations between citrus fruit intake and prevention of chronic diseases make promotion of citrus consumption important in improved human health.

From the review of Kader, the quality fresh fruits are determined by many factors and properties which give the produce a value as food [6]. The quality of fruits is perceived based on good look, the firmness, good flavour and the nutritional quality. If a product is not safe, it does not matter what its quality is; it should be eliminated from the produce distribution system.

The methods of harvesting (hand vs. mechanical) can significantly impact upon the composition and post-harvest quality of fruits. Management of harvesting operations, whether manual or mechanical, can have a major impact on the quality of harvested fruits. Proper management procedures include selection of optimum time to harvest in relation to product maturity and climatic conditions, training and supervision of workers, and proper implementation of effective quality control.

In horticultural industry, conventional harvesting is done by 'handpicking' methods to remove hundreds of fruits such as citrus fruits in random spatial locations on the individual fruit trees. It is well known that harvesting fruits on a large scale is still inefficient and not cost effective. To solve this challenging task, mechanical harvesting systems have been investigated and practised to enhance profitability and efficiency of horticultural businesses. However, they often damage fruits in the harvesting process. Development of efficient fruit removal methods are required to maintain the fruits quality.

All citrus fruits must be picked, handled and packed properly to avoid damage or potential damage when storing and transporting to the market. Many factors affect fruit quality, viz bad weather patterns, cultivars, rootstock, cultural practices, water management, nutrition, pests and diseases. The price of the citrus fruit is determined by the quality. These challenges especially pests and diseases compel growers to treat the fruit to maintain its quality. Citrus fruit quality depends on the external appearance-fruit size, rind colour and the degree of rind blemishes and the internal fruit quality-Total Soluble Solids (TSS), acids, plus the degree of sourness or aromaticity [6].

With the importance of citrus in this modern life of the people of Ghana and the scarcity of studies on the harvesting and its effect on the fruit quality is missing. Therefore, studies to

addressing this issue become relevant. In this context, the work is aimed to investigate the effects of harvesting methods on the quality characteristics of orange fruits.

1.2. Statement of the Problem

In Ghana, the focus of the various stakeholders in the Horticultural industry has mostly been on improved production capacities of farmers. However, after investing so heavily in producing the fruits, farmers' produce are lost in the harvesting processes and postharvest chain. As observed by [7] the agricultural sector in general and the citrus sector in particular have not met their potential as a result of production seasonality, high perishability of the citrus fruits making it insufficient in the market, lack of a reasonable alternative uses of the citrus fruits and poor pricing. It is probable that, poor harvesting leads to such challenges.

These scenarios most obviously reduce the quality characteristics of the fruits. Again, the intervention of ADRA's food security project was meant to reduce poverty and increase income levels of rural farmers, any practice that will result in losses both on and off the field should be critically considered in order to realize the project objective [8]. Perceptibly, any effect of harvesting methods has consequences on the quality of the orange fruits of which traders and consumers use in buying. Moreover, the high-demand production and steadily increased consumption of orange fruits make it stand tall among fruit crops. Orange fruits have been recognized as an important food and integrated as part of our daily diet, playing key roles in supplying energy and nutrients in health promotion and purported protection from various chronic diseases. Indeed, the quality substance of the citrus fruit that promotes such a healthy living among individuals should be sustained.

Therefore, the study of investigating the effects of harvesting methods on the quality characteristics of orange fruits is of great importance to the stakeholders of the citrus industry, such as citrus farmers, citrus traders and all the consumers of orange fruits in Ghana.

1.3. Objectives of the Study

The following objectives were formulated to guide the study:

- 1) Identify the type of harvesting method mostly used by the citrus farmers.
- 2) Identify consumers' preferred citrus variety in the market.
- 3) Determine postharvest practices that cause injuries to citrus fruits.
- 4) Determine the effects of harvesting methods on the fruits quality characteristics.

2. Literature Review

2.1. Harvesting of Citrus Fruits

According to fruit-crop.com, all citrus are non-climacteric fruit, meaning that they ripe gradually over weeks or months

and are slow to abscise from the tree. The external colour changes during ripening, but is a function of climate more than ripeness, and a poor indicator of maturity. Knowing when to harvest any citrus fruit involves the question of its degree of maturity. Citrus fruit is slow to ripen, and will be ripe about 9-11 months after pollination. In order to produce ripe fruit, citrus trees require temperatures greater than 14°C (55°F), for at least 6 months after flowering (fruit-crop.com). Unlike other types of fruits, citrus does not continue to ripen once it is picked from the tree. According to fruit-crop.com, there is no ripening process in citrus fruits and no such thing as "tree ripe" fruit. Citrus fruits pass from immature to mature and finally to an over mature condition while remaining on the tree, but the changes are slow and spread over several months. Fruit colour is a poor indication of ripeness, because many fruits have fully coloured rinds a long time before they can be eaten and some fruits are green when the sugars are high enough to make a delicious tasting citrus. The principles dictating at which stage of maturity a fruit should be harvested are crucial to its subsequent storage and marketable life and quality. According to Post-harvest physiologists there are three stages distinguished in the life span of fruits: maturation, ripening, and senescence [9]. Maturation is indicative of the fruit being ready for harvest. The ripening follows or overlaps maturation, rendering the produce edible, as indicated by taste. Senescence is the last stage, characterized by natural degradation of the fruit, as in loss of texture, flavour, etc. A study conducted in Zimbabwe by Kadzere et al indicate that the time of the year, colour changes, skin softness and abscission, were the indicators used by most growers to determine ripening of fruits [10]. But [9] noted in their bulletin 149 that the only way for growers to determine maturity is to taste the fruit but the best indices of maturity for citrus are internal: sugar, juice content, acid content, total content of soluble solids and the acid ratio.

Harvesting is the operation of removing fruit from trees and delivering it to the point where it is packaged or processed into products. According to the Citrus Academy as stated in citrus harvesting guide, citrus is hand harvested, whether processed or marketed fresh but mechanical harvesters have been used in advanced countries. For instance, in Florida it is increasingly gaining popularity due to high labour costs and lack of labour availability. A large number of unskilled, seasonal workers are employed in removing fruit from trees.

Kadzere et al. Indicated in their study that citrus fruit harvesters climb the tree to harvest because it did not readily abscise when ripe [10]. Ideally, hand picking is used with secateurs to cut the fruit from the branch leaving a short stem. The use of bag and ladder is the most widely used method of harvesting citrus fruits. It has been tailored to meet the special needs of different cultivars.

According to them, most of the harvesters collect fruits that dropped naturally. However, others shake the trees or throw objects at the tree crown, hitting the stem, etc. to dislodge the fruits thereby damaging tree stems and branches.

When picking citrus fruit to store for a while, it important

to be careful not to bruise or break the skin. Harvesting the fruit should involve clipping ripe fruit off with pruning shears instead of pulling it to avoid skin damage. When picking the fruit, firmly grasp it in your hand and turn it to a 90-degree angle and pull. The fruit should easily snap off the branch. If the rind tears, use a pruning knife or clippers to detach the fruit stem from the branch. Fruits that are cut or scratched during harvesting will rot fairly quickly in storage. [9] caution that citrus fruits with perfectly sound skin are fairly decay proof, and will last in cool, moist storage for several weeks (38 to 48 degrees F., 85 to 95 per cent relative humidity). Under dry conditions at room temperature, fruits develop off-flavours and shrivel within a week to 10 days (Fruit Academy).

Lee and Kader, noted that poor harvesting and rough handling at the farm directly affect market quality and nutritive value of fruits [11]. It has also been stated that mechanical injuries, such as bruising, surface abrasions and cuts, can result in fungal infection, increased respiration rate, ethylene production, dehydration of tissues and water loss and accelerated losses in vitamin C.

2.2. Effect of Harvesting on the Fruit Quality

Faulty harvesting and poor handling of the fruit directly affect market quality and nutritive value of fruits [12]. Mechanical injuries, such as bruising, surface abrasions and cuts, can result in fungal infection, increased respiration rate, ethylene production, dehydration of tissues and water loss and accelerated losses in vitamin C [11, 6, 13]. Even, [14] added that Mechanical injuries can accelerate loss of water and vitamin C resulting in increased susceptibility to decay-causing pathogens. The traditional method of harvesting orange fruits in Ghana causes bruises and injuries to the fruits, and later makes them unattractive and shortens their shelf-life. This study examines the effects of the traditional method of harvesting orange fruit on the quality. Mechanical damage during harvest can become a serious problem, as injuries predispose produce to decay, increased water loss and increased respiratory and ethylene production rates leading to quick deterioration. However, manual harvesters should be well trained in the proper way to harvest the crop to minimize damage and waste, and should be able to recognize the proper maturity stage for the produce they are handling.

Exposure to the sun should be avoided as much as possible during and after harvest, as produce left out in the sun will gain heat and may become sun-burned [14]. Orange fruits exposed to sunlight can soon become 4 to 6°C (7 to 11°F) warmer than air temperature [15]. Field bins should be placed in the shade or loosely covered (for example with light coloured canvas, leafy plant materials, straw or an inverted empty container) if delays are expected in removing them from the field. Night or early morning harvest is sometimes an option for harvesting orange fruit to maintain its quality.

3. Methodology

The study was a survey which was carried out on the field to determine the harvesting methods used by the citrus farmers through the use of questionnaires. The survey was carried out in two different districts; Abura-Asebu Kwamankese and Mfantseman. Three sets of different questionnaires were administered to three stakeholders in the citrus chain production; the farmers, sellers and consumers. A total of one hundred and (140) sample size was used for the survey. The sample size consisted of 50 farmers selected from 185 registered Citrus Growers Associations of both Abura-Asebu Kwamankese and Mfantseman Districts. 50 wholesalers of citrus fruits and the remaining 40 consisted of consumers of citrus fruits were also randomly selected from the two districts.

4. Results

4.1. Harvesting Methods Used by Citrus Farmers

The first objective of the study sought to determine the types of harvesting methods used in harvesting citrus in the study area. The findings are presented in Table 1.

The findings indicated that most farmers (46.4%) used hook method to harvest their fruits. The next frequently used method was hand picking (32.9%) whiles 20.7% of the respondents used shaking of branches as their harvesting method.

Table 1. Harvesting methods.

Harvesting method	Frequency	Percentage
Shaking of the branches	29	20.7
Hand picking	46	32.9
Using hook	65	46.4

4.2. Consumers' Preferred Citrus Variety

The research objective two sought to determine the consumers prefer citrus variety in the market. Respondents were provided with the three common citrus varieties which are cultivated in the study area. The varieties were the Local Med, the Late Valencia and the Mediterranean Sweet. Figure 1 shows the graphical presentation of the consumers' preferred varieties in the market.

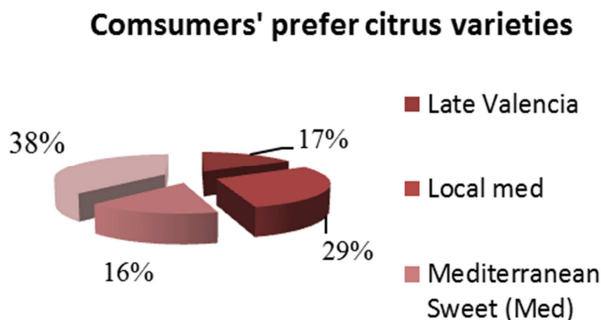


Figure 1. Consumers' preferred citrus varieties.

From figure 1 it shows that most respondents (37.9%)

cultivate, sell or buy two or more varieties. The next preferred variety was the Local Med consisted of 29.3% of the respondents. The Late Valencia and Mediterranean Sweet had 16.4% representing 23 of the respondents.

4.3. Postharvest Practices That Cause Most Injuries to the Citrus Fruits Which Affect Its Quality

The research objective three sought to determine the post-harvest practices that cause most injuries to the citrus fruits that affect their quality. Item 11 consisted of seven practices were given to respondents to rate them as 1-lowest damage up to 5 as the highest damage. Table 2 shows the descriptive results of the rated items.

Table 2. Post-harvest practices that cause injuries to the fruits.

S/N	Item	Mean Score	Std. Deviation
a.	Harvesting	4.45	1.13
b.	Cracks /pieced fruits	4.08	1.33
c.	disease and pest activities	4.76	0.66
d.	bad handling practices	4.28	1.25
e.	Transportation	2.71	1.45
f.	packing of fruits	2.01	1.01
g.	Loading into the vehicle	1.95	1.14
h.	Assembling	1.40	0.87

From Table 2, four of the practices (a, b, c, and d) were considered the most common practices that cause more injuries to the fruits. Disease and pest activity was considered as the highest. Harvesting methods also became the second highest activity with a mean score of 4.45 and Standard Deviation of 1.13 cause injuries to the fruits. This was followed by bad handling practices with a mean score of 4.28 and std. deviation 1.25. Cracks and pieced fruits also recorded a mean score of 4.08 and std. deviation of 1.33.

Four activities such as assembling, loading, packing and transportation even though contribute but they were not as high as other activities. Assembling and loading of fruit into the vehicle were considered as activities that do not cause much damage to the fruits with a mean score of 1.40 and std. Deviation 0.87 and mean score 1.95 and Standard Deviation 1.14 respectively.

In the nutshell, disease and pest activities, harvesting methods, bad handling practices and cracks and pieced were the most serious activities that cause damages to the fruits.

4.4. Effects of Harvesting Methods on Citrus Fruit

The research objective four sought to determine the effect of harvesting methods on the citrus fruit quality. First, respondents were asked to determine how the harvesting method affect the citrus fruit and second, they were asked to the result has been presented in Table 3 whiles the result of whether the harvesting method has effect on the fruit quality has been presented in Table 4.

Table 3 indicate that 46.4% (65) of the respondents used hook method, 32.9 (46) of the respondents used hand picking and 20.7% (29) of the respondents used shaking of branches. Finding out which method causes much injuries to the fruit (item 2), 62.9% (88) respondents noted shaking of branches

and 37.1 indicated using hook, none of the respondent indicated hand picking. However, 49.3% (69) of the respondents believed that using hand picking harvesting method reduces fruit injuries as compared to 32.9 (46) hook method and 17.9% (25) shaking of branches. Fifty percent (50%) of the respondents indicated shaking of the branches as poor harvesting method while 45% of the respondents

indicated hook method. From the Table 3, 52.9% (74) of the respondents indicated that shaking of branches as most harvesting method that affect the taste of the citrus fruits, followed by using hook with 47.1% (66). The result also revealed that 60.0% (84) of the respondents noted shaking of the branches affect the shelf life of the citrus fruit, while 40.0% (56) of the respondents indicated hook method.

Table 3. Harvesting methods used in harvesting citrus fruits.

S/N	Item	Shaking of branches	Hand picking (Plucking and catching)	Using hook
1	Which harvesting method causes much injury to the fruits?	62.9% (88)	0.0% (0)	37.1% (52)
2	Which harvesting method reduces injury to the fruits?	17.9% (25)	49.3% (69)	32.9% (46)
3	Which of the following is a poor harvesting method?	50.0% (70)	5.0% (7)	45.0% (63)
4	Which harvesting method affects the taste of the fruits?	52.9% (74)	0.0% (0)	47.1% (66)
5	Which harvesting method affects the shelf life of the citrus fruit?	60.0% (84)	0.0% (0)	40.0% (56)

N=140.

In a further examination on the effects of harvesting method on the fruit quality, respondents were given 8 items to rate in order as 1-Strongly Agree, 2-Agree, 3-Uncertain, 4-Disagree, 5-Strongly Disagree. The results have been presented in Table 4.

From Table 4, most of the respondents agreed to the fact that item vi (harvesting method affect the citrus fruit quality)

has effect on the fruit's quality with a mean score of 2.16 and standard deviation 1.37. It was not surprising that the respondents agreed to item i (Poor harvesting method affect the fruit juice) with the mean score of 1.37 and standard deviation. 48. Again, the respondents indicated that the drop height of the citrus fruits (item viii) affect their quality.

Table 4. Effects of harvesting methods on the fruit quality.

S/N	Item	Mean	Std. Deviation
I	Poor harvesting method affect the fruit juice	1.37	0.48
Ii	Hand picking method affect the fruit quality	4.36	0.67
Iii	Shaking the branches as harvesting method spoils the rind	1.45	0.83
Iv	Using hook to harvest citrus fruit is effective	4.06	1.05
V	Poor harvesting method affects the sugar content	3.20	1.50
Vi	Harvesting method affects the citrus fruit quality	2.16	1.37
Vii	Proper harvesting method maintains citrus fruit quality	1.26	0.44
Viii	Does the drop height affect the citrus fruit quality?	1.69	.62

N=140.

The respondents disagreed to item ii (Hand picking method affect the fruit quality) and item iv (using hook to harvest citrus fruit is effective) with mean score 4.36 and 4.06 respectively. However, respondents were uncertain about item v (poor harvesting method affect the sugar content) with a mean score of 3.20 and standard deviation 1.50.

From the results, it was concluded that poor harvesting method (shaking of branches) has adverse effects on the citrus fruit and the quality while good harvesting methods maintains the fruit quality. It was also revealed that fruit juice and rind are affected when poor harvesting methods are used.

5. Discussion

Citrus is one of the most important fruit crops grown by both large and small scale farmers in Ghana. Harvesting of oranges fruits has been the biggest challenge in the citrus production especially in the commercial production. Faulty harvesting method of the fruit directly affects market quality and nutritive value of fruits. In recent years the horticultural industry has effort to develop a more mechanical process in the harvesting systems [6]. As a part of the means of

investigating the effect of harvesting methods and post harvesting treatments on the fruit quality, types of harvesting methods used in harvesting the fruits were determined. Earlier on it was noted by Kader that the, conventional harvesting method in the horticultural industry is by 'handpicking' methods [6]. However, this current study finding revealed that "hook harvesting method" was being used by most farmers (46.4%) as hand picking method was the next preferred harvesting method (32.9%) while shaking the branches was the least method respondents used (20.7%). This finding partly confirmed Kadzere, et al. assertion that citrus fruit harvesters use hand picking method, shaking method, using hook to pluck the fruits [10].

Indeed, whether manual or mechanical, the harvesting method can have a major impact on the quality of the harvested fruits. Therefore, the next task was to determine whether harvesting method used by the citrus farmers has effects on the orange fruit quality as it was earlier noted

Accordingly, maintenance of good external appearance, without visible injuries or defects, and preservation of internal organoleptic and nutritional quality, are essential quality attributes for maintaining high quality citrus fruit for

domestic and foreign markets. Throughout the postharvest chain, fruits are subjected to many practices that may influence their storage life and quality.

This study found out in each stage of the harvesting the fruit quality is affected. The assembling, loading, packing and transportation also contribute to fruits injuries but in a minimal degree. These findings further support the ideas of Adel and Rosa poor harvesting methods are major causes of fruits injuries [14].

Even though, Riccarda, Roberta, and Thilmany-McFadden posit that useful cultivar must score high in yield, disease resistance, ease of harvest and shipping quality but producers are concerned that their commodities have a good appearance and few visual defects [7]. On the other hand, consumers consider good quality fruits to be those that look good, firm, and offer good flavour and nutritional value. If a product is not safe, it does not matter what its quality; it should be eliminated from the produce distribution system. Once again, Lee and Kader has earlier noted that the quality of the fruits depends upon the external appearance-fruit size, peel colour and the degree of peel blemishes and the internal fruit Quality-Total Soluble Solids (TSS), acids, plus the degree of bitterness or aromaticity [11].

The finding from this study indicated that majority (67.9%) of the respondents noted that shaking the branches was the poorest harvesting method that causes more negative effects on the citrus fruit quality followed by the hook harvesting method. This finding is in agreement with the earlier finding of Mohammed assertion that improper harvesting methods influence the physical and mechanical losses of the fruit quality [12]. In one way or the other, the harvesting methods had effect on the fruit weight, fruit juice weight, juice content, fruit diameter, vitamin C content [5].

6. Conclusion

Citrus fruit is now becoming the fastest staple food product in the daily diet of many people. The large consumption of citrus can also be attributed to fact that it serves as food and used as flavour in most beverage industries. It is very important that the maintenance of good external appearance, without any visual injuries or defects and preservation of the internal nutritional quality should be a primary concern to the producers, sellers and consumers as well. Indeed, the ideal harvesting method should be hand-picking. The picking of the fruit should be done by the hand, normally with a slight twist of the wrist, which leaves the 'button' or calyx on the fruit. Pulling the fruit usually causes the button being removed and even breaks the skin at the stem end. The citrus fruit can be considered a too delicate fruit for mechanical harvesting, based on the fact that height of the plant, excessive damage of the fruit may occur. In fact, it would be impossible to use shaking method without causing damage to the immature fruits on the tree at the time of harvest. Again, shaking may reduce the pack out of the high grades and cause more injury from cuts and abrasions than the hand-picking.

The quality of the fruits depends on the external appearance and the internal quality. It is also essential to note that the price of the citrus fruit largely depends on the appearance and the quality.

7. Recommendations

Traditional harvesting comes with different challenges such as postharvest losses, time consuming and labour intensive therefore it is recommended that farmers should start embracing mechanical harvesting. Special treatments may be applied before, during or after harvesting the fruits and should be supplements to the normal and basic practices of covering the fruits, grading, selecting, cleaning, and temperature and humidity management, therefore should never be considered as replacements for such practices.

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