Effect of Postharvest handling on Quality Attributes of Passion Fruits (*Passiflora edulis Sims var.)*

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Abstract

In Kenya, Passion fruit is becoming part of solution in staving- off hunger and malnourishment. Most of the underutilized fruits passion fruits included are often among those which have the greatest potential in terms of nutrition and income generation for small holders. Passion fruit is underutilized because of the significant amounts that go into waste during peak production. The objective of this study was to evaluate the effect of postharvest handling on quality of passion fruit (Passiflora edulis sims var) in Uasin -gishu county. Four hundred and eighty (480) passion fruits were harvested from farmer's fields in Soy and Kapseret sub-counties in Uasin Gishu County and postharvest treatments applied, this included harvesting at two color maturity stages (at 75% and 25% colouring), detachment of the fruit with a 5 cm stalk attached and others with no stalk attached, storage of fruit under ambient conditions and others in polythene sheets. Treated fruits were then taken to Chemelil Sugar Company Laboratory where they were stored and analyzed periodically for 28 days. The experiment was laid out in a completely randomized design (CRD) with three replicates. Passion fruits were analyzed for Weight change during storage, Total Titratable Acidity (TTA), Total Soluble Solids (TSS) and Pulp weight. The data collected was subjected to Analysis of Variance (ANOVA) using GenStat version 14th edition. The color at which passion fruit was harvested greatly affected its titratable acidity, pulp weight and its brix. In addition the mode of storage significantly impacted the fruit total titratable acidity, pulp weight and whole fruit weight. On the other hand the point at which the fruit was detached from the mother plant did not significantly affect the measured quality attributes other than total titratable acidity. Storage interval significantly affected the measured quality attributes of passion fruit The key aspects that the farmers in Uasin Gishu County should observe when harvesting the produce include; harvest the produce at 75% color maturity stage as well as employ the use of recommended modified atmosphere packaging material as this will greatly impact the fruits chemical and organoleptic quality attributes thus influencing its shelf life.

Key Words: Postharvest handling, Underutilization, Quality attributes

INTRODUCTION

Passion fruit (*Passiflora edulis*) a native of tropical America, belongs to Passifloraceae family which comprises of about 530 species. Among the species, yellow passion fruit (*Passiflora edulis flavicarpa*), purple passion fruit (*Passiflora edulis)* and giant variety (*Passiflora quadrangular is*) are the widely cultivated (Joy, 2010).

The purple passion fruit is considered to have originated from southern Brazil through Paraguay to northern Argentina (Acland, 1971; Morton, 1987). In Kenya, purple passion fruit farming was introduced around 1920's and was expanded in the mid 20th century. The

fruit is mainly grown in the Rift valley region (Elgeyo- Marakwet and Uasin-gishu counties), Eastern (Meru and Embu counties), Central (Murang' and Kiambu counties), Western (Bungoma county) and Nyanza (Kisii county) regions (Amata *et al.,* 2009).

Passiflora edulis variety is purple and grows and produces well at altitude of 1200 m above sea level and temperature range from 8-20^{0}c. The plant remains productive all year round in more tropical areas (Gaturuku and Isutsa, 2011).

There are several harvest maturity indices of passion fruit; they include the time after transplanting and external skin colour. Chen and Robert (2014) postulated that fruits that are harvested when they are ≥ 75% turning yellow or purple, continue to stay that Purple. Important quality considerations in passion fruits include a consistent and fresh appearance, acceptable texture, characteristic flavor, and sufficient shelf-life to survive the distribution system (Watada, 1996). This therefore means that harvesting has to be done at a stage that gives a ripened flavour or rather an appealing organoleptic taste with a compromise stage that allows for long distance transport.

Film-bagging and various coatings helps reduce water loss in yellow and purple passion fruit during storage although it is said that response to coatings and film bagging may be associated with control of water loss, rather than modified atmosphere effects (Chen and Robert, 2014). Elsewhere it is said that plastic films and waxes increase post-harvest life because fruit respiration occurs inside the coating and consequently there is a reduction in the concentration of O_2 and an increase in CO_2, and an atmosphere with high relative humidity is formed, thus reducing water loss by transpiration (Fonseca *et al*., 2000).

Wounding is said to induce signals that elicit physiological and biochemical responses in both adjacent and distant tissues that not only directly affects appearance attributes (skin and flesh skin lesions and browning) but also creates sites for pathogen infection and water loss (Wu, 2010).

Passion fruit utilization faces several setbacks such as huge postharvest losses estimated at 10-60% of the harvested fruits (Mitra, 2008). Minimizing postharvest losses of already produced fruit is more sustainable than increasing production to compensate for these losses; unfortunately this is usually complicated by the nature of mechanical, physiological and pathological factors and weak post-harvest technologies causing deterioration (Food Agricultural Organization, 2004).

Uasin-gishu county is said to be a major 'bread basket' as is associated with maize, wheat and dairy farming but the trend is now shifting towards horticulture particularly passion fruits farming, which is known to have more returns compared to other enterprises (Horticultural News, 2012; Sambu, 2012).

Apparently there is clear relation between the use of film bagging (packaging) and control of water loss. However, there was need to establish distinctively how use of film bagging influences other quality attributes of passion fruit such as soluble solid content, titratable acidity, flavor taste, weight and appearance.

This study was aimed at evaluating four postharvest handling treatments (color maturity index, point of detachment from mother plant, mode of storage and length of storage) and

how it affects quality attributes specifically; pulp yield, titratable acidity(TTA) total soluble solid(TSS) and overall Passion fruit weight.

MATERIALS AND METHODS

Fruits from two sites Soy (Site A) and Kapseret (Site B) were picked. The general characteristics of the sites are shown in Table 1. In all cases the fruits selected were healthy and uniform sized. The fruits were then transported to Chemelil Sugar Company. On arrival at the company's Agronomy Laboratory, the fruits were pre-cooled and later stored in a ripening chamber (27 ± 1) ^{0}C and 50 % RH. The time gap between harvest and final storage did not exceed 24 hours.

Table 12: Description of the study area

Population	Kapsaret	Soy	Source
Area(km^2)	451.00	702.9	(Uasin-gishu, 2015)
Population	121178	171941	(Uasin-gishu, 2015)
Density/km^2	268.7	244.6	(Uasin-gishu, 2015)
Altitude (ma.s.l.)	2043	2116	(Uasin-gishu, 2015)
Rainfall(mm)	900-1200mm	600-1200	(Uasin-gishu, 2015)
Temperature ranges(^{0}c)	7^0c-29^0c	7^0c-29^0c	(Uasin-gishu, 2015)
Soils	Ferralsols	Ferralsols	(Uasin-gishu, 2015)

Source: UG County, 2015.

Experimental Design

Passion fruit (*Passiflora edulis Sims var*.) were picked from the two sites (Soi and Kapsaret) sites which had been harvested at two maturity stages namely when the colour turned 25% (a_0) and 75 % (a_1), respectively. The skin color was determined by visual expression. Secondly, detachment from mother plant was at two points that is fruit shoulder (b_0) and leaving a stricture attached (b_1) using a pocket knife. They were stored under two conditions that is ambient storage conditions (c_0) and under polythene film (c_1).The fruits were exposed to postharvest storage treatments and analyzed at periodic intervals of 7 days with initial storage interval as the starting point. The treatments were combined in CRD factorial experiment, resulting in total of 80 treatments combination (2x8x5) with three replication resulting to 240 observations (2x8x5x3). There was another 48 observations (2x8x3) for the weight; these fruits were maintained throughout the experiment period.

Weight

An electronic weighing balance, with an accuracy of 0.01g was used to measure the weight of fruits. The weight of the fruits was taken periodically after every 7 days interval for a period of 28 days. It is important to note that the fruits subjected to weight measurements were selected and maintained for the whole experiment period.

Pulp Yield

The pulp of the fruits was manually scooped using a spatula and weighed. Thereafter, the pulp was sieved through a nylon cheese cloth and recovered juice was used for measurement of fruit quality parameters.

Fruit Quality Analysis

For determination of total soluble solids (TSS), one drop of the juice was used with a calibrated bench top refractometer and readings made corrected against the prevailing room temperature (Dadzie and Orchard, 1997). Total titratable acidity (TTA) was determined by titrating 0.1 M NaOH against 1ml of fruit juice solution in a ratio of 1: 9 water as the amount needed to obtain neutral pH of 7 (Fernandes *et al*., 2011). Fruit quality parameters was taken and recorded at 7-day intervals for 28 days.

Statistical Analysis

The data obtained for different parameters during the storage period were subjected to analysis of variance (ANOVA) with maturity stage, point of detachment, mode of storage and storage time as sources of variation. The comparison among means was performed using the HSD Tukeys test at a significance level of $P<0.05$. All the analyses were performed using procedure of the GenStat analysis system 14th edition.

RESULTS AND DISCUSSION

The decline in weight of passion fruit harvested at the two color maturity indices (Table 2) may be attributed to transpiration water loss which is a major component of fresh produce tissue (Kitinoja, 2002). In this study, the differences in the weights of the fruits harvested at the two color maturity indices could be due to a number of reasons. Firstly, fruits harvested at 75% color maturity stage had higher accumulation of sugars compared to those harvested at 25% colour maturity stage. Sugars are osmotically active drawing in water across the semi permeable membrane of the fruits thus increasing their weight (Ahmad and Siddiqui, 2015), secondly, respiration rate of the produce is affected by stage of development of the fruit. Fruits at 75% colour maturity stage are more mature than those at 25% colour maturity stage (Aked, 2002). Immature fruit tissues have a higher rate of respiration than mature fruit tissues. Therefore, the higher the rate of respiration, the more weight the fruit loses. Thus in immature fruits, stored organic materials are metabolized giving off water, energy and CO_2 by products (Fonseca *et al*., 2000).

Table 2: Colour maturity index effect

Treatment	Titratable acidity	Pulp weight	Brix	Weight
a_0	34.92a	21.08b	14.63b	38.48a
a_1	30.84b	22.01a	15.08a	39.31a
F-Probability	<0.001	<.05	<.05	>0.05
Cv (%)	22	20.4	8.4	13.7
SED	0.66	0.4	0.11	0.487

NB: Means followed by the same letter in the column are not statistically significant

The high significance ($p <.05$) of the color stage at which passion fruit was harvested on brix as shown in Table 2 above could have been among other factors be due to the fact that concentration of soluble solids in a produce depend on maturity stage of the produce at harvest (Aked, 2002). Therefore, passion fruit harvested at 25% purple could not have accumulated sufficient total soluble solids compared to those harvested at 75% colour maturity stage. Thus, the lower soluble solids recorded in fruits harvested at 25% purple in agreement with (Arjona *et al.,* 1991). Tingbani (2012) has also stated that the increase in soluble solids content is because of hydrolysis of sucrose which is a complex carbohydrate into sugars.

As relates to how color maturity stage affected the total titratable acidity is that fruit harvested at advanced maturity stage at 75% color stage had a low titratable acidity (Table 2), the results of previous study (Nunes *et al.*, 1995) have supported this study in that fully matured strawberries fruits showed lower titratable acidity. During advanced stages of ripening, organic acids are broken down with an aid of Kinase enzyme which facilitated the reduction in the acidity with progressive ripening (Han *et al.*, (2015); (Norman, 1986). Color maturity index used in the study had significant effect on pulp weight of the fruits. From the results presented in Table 2, passion fruit harvested at 75% CMS had the highest pulp weight (22.01 g) compared to those harvested at 25% CMS that weighed 21.08 g. This could be attributed to the fact that at 75% CMS, the fruits are mature and have accumulated sufficient biomass compared to those harvested at 25% CMS. Pulp weight in essence represent the edible portion of fruit in the fresh produce consumer market and therefore harvesting of fruit ought to be done at a maturity stage that yield as much edible portion as possible (Fernandes, 2009).

In this study, there was no significant effect ($p>0.05$) of part in which passion fruit was detached on weight (Table 3). However, the difference in the means of the two points of detachment indicates that detachment of the fruit at its shoulder will compromise its weight as any wounds created during detachment would create openings through which water is lost through evaporation thus a reduction in fruit weight (Tingbani, 2012)

Table 3: Effect of detachment point on quality

Treatment	Titre	Pulp yield	Brix	Weight
b_0	33.37a	21.58a	14.9a	38.61a
b_1	32.39b	21.51a	14.81a	39.17a
F-Probability	<0.001	>0.05	>0.05	>0.05
Cv (%)	22	20.4	8.4	13.7
SED	0.66	0.4	0.11	0.487

NB: Means followed by the same letter in the column are not statistically significant

As has been shown in the Table 3 above, the brix content did not differ significantly ($p>0.05$) between the two sections of detachment. The part in which passion fruit was detached was highly significant ($p<0.001$) (Table 3) on titre volume, with fruits detached at the fruit shoulder recording a higher titre volume compared to that which was detached leaving attached a 5cm long stricture. This difference in effect on titratable acidity could be due to the fact that fruits detached at the fruit shoulder had a disruption on the normal ripening process. A normal ripening process involves production of essential Kinase enzymes that are responsible for the breakdown of organic acids that end lowering the acidity of produce bringing it a neutral pH during storage (Kader, 2002).

Table 4: Effect of mode of storage on quality

Treatment	Titre	Pulp yield	Brix	Weight
c_0	31.96b	20.46b	14.85a	36.1b
c_1	33.81a	22.64a	14.86a	41.69a
F-Probability	<0.001	<.05	>0.05	<0.005
Cv (%)	22	20.4	8.4	13.7
SED	0.66	0.4	0.11	0.487

NB: Means followed by the same letter in the column are not statistically significant

Fruits stored under ambient condition were more susceptible to weight loss as shown in Table 4 above compared to those stored under polythene films. The role of the polythene films in weight loss reduction can be attributed to its role in maintaining a partially saturated region surrounding the produce, this creates some balance of vapor pressure within the produce and its surrounding external environment in such a scenario the rate of transpiration is reduced (Holcroft, 2015). In addition, the polythene film reduced respiration process by reducing concentration of oxygen around the produce thus the limited concentration of oxygen around the produce reduced the rate in which the metabolic substrates were broken down in fruits stored in polythene films (Rohani *et al*., 1997).

There was a high significance ($p<0.001$) between the modes in which passion fruit was stored and total titratable acidy. The fruits stored under polythene films had highest titre volume compared to those stored under ambient conditions. A high titre volume indicates that more alkali was used to neutralize the acid. Therefore, the high titre volume for fruits stored under modified atmosphere storage indicates a high acid content for fruits stored under such conditions than those stored under ambient conditions. This may be due to indirect effects of the mode of storage of reducing the level of oxygen around the stored fruits, thus reducing the rates of respiration and possibly led to partial anaerobic respirations leading to production of organic acids via physiological processes (Ahmad and Siddiqui, 2015). Thus, the lower the rate of respiration indicates that there is less reduction in substrate concentration in the fruit. In contrast, storage under ambient conditions where the fruit has been exposed to conditions favouring respiration and transpiration processes that favor reduction in substrate concentration through the action of Kinase enzymes that act on acidic compounds takes place at faster rate thus lowering acidity (Norman, 1984).

Storage period did have significant effect ($p<0.005$) on passion fruit quality in this study as shown in Table 5. The weight of the fruit decreased gradually during storage period as has been reported in studies with most fruits. This is majorly due to the fact that a produce is removed from its natural supply of water hence the immediate effect is a reduction of saleable weight while continued water loss results in wilting and shriveling (Kays and Paull, 2004). Total soluble solids did increase from the initial day of storage to the second storage interval but it finally dropped progressively in later stages. The reason for this could be attributed to the fact that at early storage period complex carbohydrate in the form of sucrose were being converted to simple sugars thus increasing soluble solids. However, with an increase in the storage period the soluble solids levels decreased as the sugars were being broken down thus releasing energy and water, this is because produce storage results in natural aging of the produce (Pongener *et al*., 2014)

Table 5: Effect of length of storage on quality

Treatment	Titre	Pulp yield	Brix	Weight
1(day 1)	47.01a	23.35a	16.079b	43.24a
2(day 7)	33.85c	21.63c	16.129a	40.27b
3(day14)	29.74d	21.95b	14.975c	37.15d
4(day 21)	35.63b	20.84d	14.001d	34.61e
5(day 28)	18.18e	19.96e	13.085e	39.20c
F-Probability	<0.005	<.005	<.005	<.005
Cv (%)	8.5	20.5	6.3	11.3
SED	0.255	0.402	0.0849	0.402

NB: Means followed by the same letter in the column are not statistically significant

Total titratable acidity decreased gradually across the storage interval but abnormally rose in fourth storage period. The decrease is attributed to breakdown of acidic compounds by Kinase enzyme thus the pH of the produce increased as the produce became even sweeter.
The drop in pulp weight of the produce along the storage period is attributed to both transpiration water losses of the produce as well as respiratory breakdown of organic compounds in the produce that released metabolic products such water, gaseous volatiles, CO_2 among other products (Holcroft, 2015).

CONCLUSION AND RECOMMENDATION

The color at which passion fruit was harvested greatly affected its titratable acidity, pulp weight and its brix. In addition the mode of storage significantly impacted the fruit total titratable acidity, pulp weight and whole fruit weight. On the other hand the point at which the fruit was detached from the mother plant did not significantly affect the measured quality attributes other than total titratable acidity. The key aspects that the farmers in Uasin Gishu County should observe when harvesting the produce include; harvest the produce at 75% color maturity stage as well as employ the use of recommended modified atmosphere packaging material as this will greatly impact the fruits chemical and organoleptic quality attributes thus influencing its shelf life.

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