Effect of Storage Temperature and Period on Fruit Quality Characters of Recommended Sweet Orange *(Citrus sinenesis)* Cultivars in Sri Lanka

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Abstract

This study was conducted to assess the storage potential and to study physico – chemical changes of three important orange varieties in Sri Lanka. Fresh, fully matured fruits from three recommended cultivars (Arogya, Sisila and Bibile Sweet) were packed on perforated polythene bags and stored under two different storage conditions (room temperature at 22- 23 ^{0}C and in a refrigerator at 4-5 ^{0}C). The stored fruits were examined for physico - chemical characters at weekly intervals up to five weeks storage period. Results revealed that Arogya fruits can be stored up to 5th week without deterioration at both room temperature and refrigerators, but Sisila and Bibile sweet fruits started to deteriorate after 3rd and 4th weeks at room temperature storage, respectively and the storage life can be extended up to 5 weeks under the refrigerated conditions. According to the results, the Titratable Acidity (TA) was decreased and the percentage weight loss, Total Soluble Solids (TSS), TSS/TA ratio and pH increased at room and refrigerated conditions.

Key words: Sweet orange, Water loss, Total soluble solids, Titratable acidity, Storage

Introduction

Citrus, the most economically important fruit crop in the world is widely grown in developed and developing countries and certainly constitutes one of the main sources of vitamin C. There is also increased demand for "high quality fresh citrus" driven by the World Health Organization recommendations. Citrus contains the largest number of carotenoids found in any fruit and an extensive array of secondary compounds with pivotal nutritional properties such as vitamin E, pro vitamin A, flavanoids, limnoids, polysaccharides, lignin, fiber, phenolic compounds, essential oils etc.

Sweet orange (*Citrus sinensis*) is the most common among citrus fruits grown in Sri Lanka. It occupies nearly 6057 ha in year 2011 with a production of 4517 mt. As the domestic production is not sufficient to meet the national requirement, Sri Lanka has imported 6995 mt of sweet orange in 2011 and expends about Rs. 410 million (Agstat, 2012).

Sweet orange has a seasonal and perishable nature. In Sri Lanka, the major season of fruit production is between April and September, while the minor season occurs between December and February. Fruit prices therefore, fluctuate along with seasonality, wherein prices of fruits drop drastically during periods of glut and increase during the "off season". Therefore, extending storage duration without effect of fruit qualities is very much essential for good market prices for producers. A number of post harvest treatments like waxing, fungicidal dip and polythene film etc; have been used to extend the shelf life of fruits. However, the environmental consciousness among the scientists and layman has drawn attention towards increasing the use of chemicals on foodstuff and their deleterious effects on the environment and human being. The post harvest life of oranges varied with cultivars. Therefore, asses the storage potential of different cultivar is very much essential before using chemicals and other applications etc. Keeping in view the aforesaid facts, this experiment was undertaken to observe the storage

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potential of three recommended orange cultivars (Arogya, Sisila and Bibile Sweet) under room temperature and refrigerated conditions. Furthermore, the study was intended to observe the fruit quality changes of three cultivars during the above two different storage conditions.

Materials and Methods

The study was carried out in the Division of Horticulture, Regional Agriculture Research and Development Centre, Bandarawela, Sri Lanka during June to November 2012. Fruits of Arogya, Sisila and Bibile Sweet were harvested from the research field and brought to the laboratory. Defect-free oranges were selected and cleaned with a wet-piece of cloth and allowed to air dry separately. Five fruits from each cultivar were randomly selected and immediately assessed for physico-chemical characteristics such as weight, firmness, peel thickness, peel weight, juice content, titratable acidity (TA) and total soluble solids (TSS). Remaining fruits of each cultivar were randomly divided into 14 lots. Each lot was placed in a perforated transparent polythene bag separately. Seven lots per each cultivar were randomly selected and stored under cold storage at 5ºC in a refrigerator and other 7 lots per each cultivar were stored under room temperature. At weekly intervals, 5 fruits per each cultivar were randomly selected from fruits stored under cold storage at 5 ºC and under room temperature (27 °C). They were assessed for weight loss, peel thickness, peel weight, juice volume, pH, TSS, TA and TSS/TA ratio. The estimation of physiological loss in weight by weekly weighing of fruits and the deferential weight loss was expressed in percent with respect to storage time and storage conditions. Selected fruits were cut in half crosswise and thickness of the peel was measured in each fruit using a verniar calliper. Selected fruits were peeled separately using a sharp knife and weights of peels were measured separately using an electronic balance (CG 4102, Citizen Model). Five ml of squeezed orange juice was taken into a 10ml beaker and pH of the orange juice was recorded by using a pH meter (pH 510, Eutech instruments). The titratable acidity was determined by using standard 0.1N NaOH in the presence of phenolphthalein indicator. The total soluble solids content of the fruit juice was determined by using hand-held refractor meter (ATAGO H-50). Results were statistically analyzed in a completed randomized design.

Results and Discussion

Considering shelf life of Arogya, Bibile sweet and Sisila cultivars; different storage periods were recorded for room temperature storage and refrigerated storage except for Arogya fruits. Arogya fruits were stored for 5 weeks under both room temperature and refrigerated condition without deterioration. However, Sisila fruits and Bibile sweet fruits stored under room temperature had deteriorated after 3 weeks and 4 weeks of storage, respectively but storage period of both cultivars had extended up to 5 weeks under refrigerated conditions. The percentage of weight loss was significantly ($P \leq 0.05$) increased in "Arogya", "Bibile sweet" and "Sisila" sweet orange cultivars throughout storage period under both room temperature storage and refrigerated storage. Maximum percentage of weight loss was observed in Sisila fruits stored under room temperature as 12.97% in third week of storage. Minimum percent of weight loss was observed in Arogya fruits stored under refrigerated conditions followed by under room temperature (Table 1). It was 4.54% and 4.62% respectively even after fifth week of storage period.

This trend in weight loss of orange fruits with storage period is in agreement with Tabatabaekoloor (2012). He reported that the weight loss of "Thompson" navel orange (*Citrus sinensis*) fruits increased with storage period under ambient (14 ºC, 67% RH) as well as

refrigerated conditions (5 ºC, 85% RH) at the end of 30 days storage and the weight loss in ambient and refrigerated storage conditions was 13.9% and 4.7%, respectively.

According to the results, peel thickness and peel weight of three sweet orange cultivars were decreased under both room temperature storage and refrigerated storage throughout the storage period and decrease of peel thickness and peel weight were higher in orange

Table 1. Effect of temperature on the physico -chemical characteristics of three orange cultivars

Storage period	Weight loss%	Peel thickness (mm)	Peel weight (g)	pH	Total soluble solids	Titratable acidity	TSS/TA
Refrigerated storage (5 °C)							
Var. Arogya							
Initial	0.00^{d}	0.88^{a}	63.55^{a}	2.75^{c}	13.2^{b}	2.00^{a}	6.64^{b}
1st week	1.07^{c}	0.69^{b}	57.74^{a}	2.78^{bc}	13.9^{ab}	1.95^{ab}	7.14^{ab}
2nd week	2.09^{bc}	0.65^{b}	57.06^{a}	2.81^{abc}	14.0^{ab}	1.93^{ab}	7.29^{ab}
3rd week	2.38^{b}	0.61^{b}	54.02^{a}	2.84^{ab}	14.1^{a}	1.87^{ab}	7.59^{a}
4th week	4.06^{a}	0.56^{b}	53.58^{a}	2.84^{ab}	14.2^{a}	1.82^{ab}	7.81^{a}
5th week	4.54^{a}	0.53^{b}	50.87^{a}	2.87^{a}	14.3^{a}	1.77^{b}	8.06^{a}
Var. Sisila							
Initial	0.00^{f}	0.57a	33.72a	3.13^{b}	12.9 ^{a}	2.00 ^{a}	6.46 ^{b}
1st week	2.03^{e}	0.52^{ab}	30.54^{ab}	3.14^{b}	13.0 ^{a}	1.82 ^{b}	7.18^{ab}
2nd week	3.96^{d}	0.49^{ab}	26.99^{bc}	3.16^{b}	13.1 ^{a}	1.74 ^{b}	7.56^{a}
3rd week	5.85^{c}	0.43^{b}	24.52^{cd}	3.20^{b}	13.2 ^{a}	1.72 ^{b}	7.67^{a}
4th week	8.45^{b}	0.42^{b}	23.54^{cd}	3.39^{a}	13.3 ^{a}	1.72 ^{b}	7.73^{a}
5th week	11.16^{a}	0.41^{b}	21.17^{d}	3.40^{a}	13.3 ^{a}	1.71 ^{b}	7.77^{a}
Var. Bibile sweet							
Initial	0.00^{e}	0.55^{a}	46.44^{a}	3.09^{b}	10.5^{d}	1.68^{a}	6.24^{e}
1st week	1.25^{d}	0.48^{ab}	39.72^{ab}	3.14^{b}	10.9^{cd}	1.67^{a}	6.52^{de}
2nd week	2.22^{d}	0.47^{ab}	34.29^{b}	3.15^{b}	11.1^{bc}	1.65^{a}	6.71^{cd}
3rd week	3.37^{c}	0.44^{b}	34.06^{b}	3.16^{b}	11.6^{ab}	1.63^{ab}	7.08^{bc}
4th week	5.95^{b}	0.43^{b}	33.90^{b}	3.23^{b}	11.8^{a}	1.59^{b}	7.41^{b}
5th week	8.72^{a}	0.43^{b}	33.57^{b}	3.41^{a}	12.0^{a}	1.52^{c}	7.85^{a}
Room temperature storage (27°C)							
Var. Arogya							
Initial	0.00^{d}	0.88^{a}	63.55^{a}	2.75^{d}	13.20^{c}	2.00^{a}	6.64^{c}
1st week	1.78^{c}	0.63^{b}	49.95^{b}	2.84^{cd}	13.80^{bc}	1.88^{ab}	7.33^{bc}
2nd week	2.11^{c}	0.61^{b}	49.29^{b}	2.86^{bcd}	14.00^{ab}	1.84^{ab}	8.06^{ab}
3rd week	3.23^{b}	0.61^{b}	49.16^{b}	2.91^{abc}	14.10^{ab}	1.68^{bc}	8.37^{ab}
4th week	4.48^{a}	0.49^{b}	48.99^{b}	2.97^{ab}	14.30^{ab}	1.63^{c}	8.83^{a}
5th week	4.62^{a}	0.47^{b}	48.72^{b}	2.68^{a}	14.60^{a}	1.61^{c}	9.21^{a}
Var. Sisila							
Initial	0.00^{d}	0.57^{a}	33.72^{a}	3.13^{b}	12.9^{a}	2.00^{a}	6.46^{b}
1st week	3.67^{c}	0.52^{a}	27.71^{b}	3.19^{b}	13.0^{a}	1.66^{b}	7.81^{a}
2nd week	6.96^{b}	0.40^{b}	25.09^{b}	3.38^{a}	13.1^{a}	1.66^{b}	7.91^{a}
3rd week	12.97^{a}	0.39^{b}	23.06^{b}	3.43^{a}	13.3^{a}	1.55^{b}	8.54^{a}
Var. Bibile sweet							
Initial	0.00^{d}	0.55^{a}	46.44^{a}	3.08^{b}	10.5^{a}	1.68^{a}	6.24^{d}
1st week	4.21^{c}	0.54^{a}	33.06^{b}	3.36^{a}	10.8^{a}	1.18^{b}	9.18^{c}
2nd week	7.99^{bc}	]0.48^{a}	32.37^{b}	3.37^{a}	11.2^{b}	1.10^{bc}	10.27^{bc}
3rd week	9.77^{ab}	0.47^{a}	31.57^{b}	3.39^{a}	11.9^{a}	1.08^{bc}	11.09^{ab}
4th week	12.63^{a}	0.42^{a}	30.78^{b}	3.45^{a}	11.9^{a}	1.01^{c}	11.95^{ab}

* Mean values with same letters are not significant ($p>0.05$).

fruits stored under room temperature than refrigerated condition. Reason for these trends in percentage weight loss, peel thickness and peel weight may be caused by the fruit transpiration in which water moved out and resulted in wilted peel and a shriveled appearance. However, weight loss % comparatively low in var. Arogya, under both room temperature and refrigerated storages and it may be due to its higher peel thickness than other two varieties.

pH of all tested sweet orange cultivars increased at room temperature and in refrigerated storage during storage period and increase in pH was higher at room temperature than refrigerated condition (5°C). Titratable Acidity (TA) of sweet orange fruits stored in both room temperature and refrigerated (5°C) condition decreased throughout the storage period and the decreases in TA of all sweet orange cultivars were faster during storage under room temperature than at 5°C. Similar trend for room temperature storage was recorded in Gloria. *et al.* (2010) for Valencia and Navel orange fruits. Serry (2010) also observed that juice acidity of Washington Navel orange subjected to Quarantine treatment (2 °C and 90% RH) for two months, followed by a marketing period at (20 °C and 65% RH) for 7 days had decreased gradually throughout storage period.

The decline in citric acid content during storage of citrus fruit might be due to the utilization of organic acids for energy production. It might be due to the conversion of organic acids to sugar through gluconeogenesis. It was also possible that acids were used for alcoholic fermentation in harvested citrus (Echeverria & Burns, 1988). Therefore, this may be leads to decrease in TA and increase in pH of sweet oranges during storage.

Maximum initial TSS 13.2 was recorded in Arogya fruits and minimum initial TSS 10.5 was observed in Bibile sweet fruits. The initial TSS of Sisila fruits were 12.9. Generally, Arogya and Sisila cultivars consider as sweeter than Bibile sweet. Our results also revealed that higher TSS values in Arogya and Sisila at harvesting stage than Bibile Sweet. Total Soluble Solids (TSS) and TSS/TA ratio of all tested sweet orange fruits stored under room temperature and refrigerated condition were increased throughout storage period and increase of TSS and TSS/TA ratio were faster in room temperature storage than refrigerated storage. According to the Gloria. *et al* (2010) increase in TSS and TSS/TA ratio of Valencia and Navel oranges were recorded under room temperature condition. In Washington navel orange fruits subjected to Quarantine treatment (2 °C and 90% RH) for two months, followed by a marketing period at (20 °C and 65% RH) for 7 days TSS and TSS/TA ratio were increased gradually throughout storage period (Serry, 2010).

Soluble solids comprise main component as sugar and in small quantities of the organic acids, amino acids and soluble pectin. TSS is generally used for sugar estimation. Normally TSS of sweet orange varies from 8 to 12% in the juice and the titratble acidity ranges between 0.5 and 1.5 %. Oranges and mandarins usually have TSS/TA ratio of 8:1 as an optimal level for marketable fruits. In present study initial TSS and TA of all tested sweet orange cultivars were little bit higher than these values but during storage TA gradually decreased and TSS further increased. Initial TSS/TA ratio of all tested sweet orange cultivars was also lower than 8 however, it increased up to marketable level during both room temperature and refrigerated storage. The decrease in acid contents and the increase in TSS resulted in the increase in TSS/TA ratio of Arogya, Bibile sweet and Sisila orange fruits stored at

25 °C and 5 °C. During storage of orange, organic acids decreased faster than sugars so that the fruit was predicted to be slightly sweeter in holding.

The results of this study showed that Arogya orange had better post - harvest characteristics and quality attributes when compared to Sisila and Bible Sweet oranges. Storing sweet oranges fruits under refrigerated condition apparently reduce the changes of physico -chemical characters of all varieties than room temperature storage and maintained higher fruit qualities. However, increase of TSS, TSS/TA ratio is not directly correlated to the sweetness and good fruit qualities. Therefore, further studies are needed to determine the effects of room temperature and refrigerated conditions on sensory attributes and consumer acceptance of Arogya, Bibile Sweet and Sisila fruits.

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