# Physico-chemical Composition of Sweet Orange (*Citrus sinensis.* cv Agege 1) with Fruit maturity in an organic production system

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**Abstract**

*This study investigated changes in the physical, biochemical and proximate composition of sweet orange (cv. Agege 1) with fruit maturity in a 7 year old orchard cultivated under organic production system of the tropical humid climate. The experiment was conducted for two consecutive early seasons between November 2014 and May 2016 at the Federal University of Agriculture, Abeokuta. Nigeria. Sweet orange trees were fertilized with 10t/ha poultry manure/tree twice in a year and fruits were harvested from 90 days after fruit set to 240 days after fruit set to evaluate for quality changes. Fruit and peel weight, juice volume, seed numbers and total soluble solids (TSS) contents of the sweet orange increased significantly ($p<0.05$) with fruit maturity. However, vitamin C content, titratable acidity and firmness decreased with fruit maturity. The peel colour of the fruits remained green with maturity.*

## Introduction

Sweet orange is an important nutritious fruit crop with a good amount of vitamin C and several phytochemicals. Generally climate has a significant effect on citrus yield, growth, fruit quality and economic returns (Zekri, 2011).Agege 1 is a popular sweet orange variety in South Western, Nigeria because of its adaptability and high fruit yield(Olaniyan and Fagbayide, 2005).

In recent times there is an upsurge in the global demand for organic fruits due to envisaged benefits to health and environment (Aiyelaagbe and Afolabi, 2006). More so, there has been scientifically provenresults that some organically cultivated fruits contain high vitamins and minerals (Odeyemi *et al,* 2014). However, maturity is one of the factors that determine the compositional quality of fruits and vegetables (Lee and Kader, 2000). Due to paucity of information on the quality of sweet orange cultivated under organic practices in Nigeria, this study was carried out to investigate the changes inphysical, biochemical and proximate composition of sweet orange (cv. Agege 1) with fruit maturity under organic production system.

## Materials and Methods

### Field management and plant materials

Sweet orange fruits were harvested from an organic fruit orchard situated at the Federal University of Agriculture, Abeokuta ($7^0$, 15'N, $3^0$ 25'E, 100m) in South western, Nigeria. This area of land lies within the tropical humid region. The location has an average rainfall of 1062.5mm with bi-modal distribution, temperature of 24.7°C -36.4°C and a relative humidity of 88.5%(Aiboni, 2001). The 7 year old sweet orange (cvAgege 1) were grafted on Cleopatra mandarin rootstock and spaced at 9.5cm between rows and 3.5 cm within rows.

**Treatments and experimental design**

The sweet orange trees were fertilized with 10t/ha poultry manure/tree twice in a year. Foliar application of 5.0ml neem (*Azadirachtaindica*) oil spray per litre of water was used for insect pest control (Lowell, 2008) while weeding was carried out with the use of a hoe thrice in the rainy season and twice in the dry season. Thirty sweet orange trees were randomly selected and fruits were tagged 90 days after set. Subsequently, the fruits were harvested and evaluated every 30 days for quality changes between 90 -240 days after fruit set in the early seasons of November 2014- May 2015 and November 2015- May 2016. The experiments was laid out in a Randomized complete block design replicated thrice.

**Assessment of fruit quality**

Harvested fruits were properly washed with distilled water to remove dirt and air dried. Physical properties of fruits determined included fruit weight by weighing individual fruits using an electronic balance (model Gallenkamp series, London). Fruit diameter was determined using a veneer caliper in the equatorial region. Fruit firmness of individual fruits was measured using a hand held penetrometer expressed as kg/force. Juice volume was determined by peeling individual orange, halved and then the juice was manually extracted with a juice extractor. The fruit juice was filtered to remove the seeds and pulp. The juice was then determined in measuring cylinder calibrated in milliliters (ml). Color change was evaluated using a colorimeter (CR-400/410, Konica Minolta, Netherlands) to measure colour coordinates in hunters L*a*b* units.

Biochemical composition determined included total soluble sugar (TSS) determined by placing juice from fresh samples on the reading surface of a hand-held Brix Refractometer (Model Atago 1140, Japan). Titratable acidity (TA) was estimated by titrating juice with 0.1 Sodium hydroxide in a beaker using 2-3 drops of phenolphthalein indicator to a pink colour end point. TA was expressed as percentage citric acid. The pH was determined with the use of a pH meter (Jenwaymodel 3310, UK) previously standardized with buffers 4 and 7. Vitamin Cwas estimated using titration method with the indicator dye 2,6-dichloroindophenol to a faint pink end point. Proximate composition was determined according to the standard methods of AOAC (2004).

**Data Analysis**

Data obtained were subjected to analysis of variance (ANOVA) using Genstat Discovery Statistical package (GenStat 2011). Means were separated using least significant difference at 5% level of probability.

**Results**

**Physical attributes of sweet orange as influenced by fruit maturity in an organic production system.**

Results showed that there was a significant increase ($p<0.05$) in the physical attributes of the harvested fruits with increasing fruit maturity from 90 to 240 days after fruit set in the early seasons of 2015 and 2016. The fruit weight, seed number, juice volume, peel weight and the fruit diameter increased with fruit maturity. However fruit firmness decreased as the fruits become more mature while the numbers of segments containing the juice vesicle (sacs) were not significant in both years (Table 1).

| Days after fruit set | Fruit weight (g) | | Seed number | | Juice volume (ml) | | Firmness | | Number of segments | | Peel weight (g) | | Fruit diameter (cm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| 90 | 64.7 | 58.4 | 4 | 3 | 17.7 | 10.7 | 10.7 | 5.3 | 10 | 11 | 19.8 | 10.6 | 4.9 | 4.6 |
| 120 | 99.4 | 73.0 | 8 | 4 | 34.5 | 26.3 | 18.3 | 5.8 | 11 | 11 | 22.7 | 12.6 | 5.3 | 5.1 |
| 150 | 187.4 | 132.8 | 11 | 9 | 42.2 | 33.6 | 29.0 | 14.6 | 11 | 11 | 30.1 | 21.3 | 5.7 | 5.9 |
| 180 | 217.7 | 196.2 | 22 | 17 | 60.9 | 38.3 | 38.3 | 24.3 | 11 | 11 | 33.3 | 33.0 | 5.8 | 7.2 |
| 210 | 231.7 | 253.3 | 27 | 28 | 64.1 | 47.0 | 66.1 | 30.8 | 11 | 11 | 34.9 | 45.4 | 6.2 | 7.6 |
| 240 | 239.5 | 255.0 | 28 | 29 | 65.8 | 47.3 | 72.9 | 52.5 | 11 | 11 | 38.5 | 46.0 | 6.5 | 7.9 |
| Lsd (0.05) | 64.3 | 58.9 | 7.9 | 6.2 | 13.9 | 11.5 | 2.9 | 3.5 | ns | ns | 12.8 | 9.6 | 0.9 | 0.8 |

Colour development on sweet orange peel with fruit maturity revealed that the fruits became significantly lighter (L* value) between 90-240 day after fruit set. The peel colour changed from dark green to light green in both years of observation (Table 2).

Table 2. **Colour development on sweet orange (Agege 1) peelwith fruit maturity**

| Days after fruit set | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|
| | L* | a* | b* | L* | a* | b* |
| 90 | 34.10 | -24.20 | 8.3 | 37.12 | 6.9 | -27.45 |
| 120 | 35.62 | -25.33 | 9.42 | 39.11 | 8.3 | -23.64 |
| 150 | 37.51 | -20.78 | 10.8 | 40.47 | 9.2 | -22.53 |
| 180 | 43.30 | -17.90 | 11.2 | 42.98 | 9.7 | -18.76 |
| 210 | 44.29 | -11.76 | 12.1 | 43.91 | 9.9 | -9.5 |
| 240 | 47.70 | -5.85 | 12.7 | 44.22 | 10.5 | -4.32 |
| Lsd (0.05) | 1.23 | - | Ns | 1.02 | ns | - |

L*=lightness (0=maximum darkness, 100=maximum lightness) a= (+a* redness/ -a* greenness) b= (+b* yellowness/ -b* blueness)

**Biochemical compositions of Sweet orange as influenced by fruit maturity in an organic production system**

The pH and TSS of the sweet orange juice increased significantly ($p<0.05$) with fruit maturity both early seasons of 2015 and 2016. Titratable acidity and ascorbic acid on the other hand decreased with fruit maturity in both years (Table 3).

Table 3. **Biochemical composition of sweet orange (cvAgege 1) fruit with maturity in an organic production system**

| Days after fruit set | Total Soluble Sugar (%brix) | | Vitamin C (mg/100ml) | | Titratable Acidity (%) | | pH | |
|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| 90 | 6.9 | 7.5 | 46.32 | 48.84 | 0.82 | 0.77 | 2.32 | 2.05 |
| 120 | 7.9 | 8.3 | 45.11 | 45.90 | 0.79 | 0.68 | 2.65 | 2.10 |
| 150 | 8.6 | 9.7 | 38.56 | 40.62 | 0.66 | 0.62 | 2.77 | 2.64 |
| 180 | 9.2 | 10.2 | 38.97 | 36.42 | 0.42 | 0.57 | 3.41 | 2.76 |
| 210 | 10.1 | 10.5 | 36.79 | 32.34 | 0.45 | 0.49 | 4.32 | 2.97 |
| 240 | 10.4 | 10.6 | 37.21 | 32.97 | 0.31 | 0.42 | 4.50 | 3.08 |
| Lsd (0.05) | 1.04 | 1.03 | 5.73 | 4.44 | 0.09 | 0.08 | 0.33 | 0.47 |

**Proximate composition of Sweet orange fruits as influenced by fruit maturity in an organic production system**

The moisture content of the fruit juice increased significantly (p<0.0.5) with fruit maturity with maximum moisture content at 93.3% in 2016 (Table 4). Water is a major constituent of the mass of the fruit. Other proximate compositions of the fruit juice showed that ash, fat, crude fibre, carbohydrate and crude protein decreased with fruit maturity both early seasons of 2015and 2016.

Table 4. **Proximate composition of Sweet orange with fruit maturity in an organic production system**

| Days after fruit set | Moisture Content (%) | | Ash (%) | | Fat (%) | | Crude Fibre (%) | | Crude Protein (%) | | Carbohydrate (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| 90 | 79.7 | 78.4 | 0.83 | 0.79 | 0.93 | 0.96 | 3.10 | 3.07 | 1.37 | 1.03 | 23.21 | 18.81 |
| 120 | 80.5 | 89.9 | 0.80 | 0.38 | 0.91 | 0.92 | 3.52 | 3.41 | 1.54 | 0.43 | 16.74 | 6.73 |
| 150 | 86.7 | 91.2 | 0.45 | 0.27 | 0.90 | 0.88 | 3.57 | 3.46 | 1.01 | 0.39 | 9.56 | 8.59 |
| 180 | 92.5 | 92.5 | 0.22 | 0.19 | 0.87 | 0.87 | 3.68 | 3.73 | 0.59 | 0.38 | 8.12 | 7.19 |
| 210 | 92.6 | 92.7 | 0.21 | 0.15 | 0.86 | 0.84 | 3.77 | 3.81 | 0.47 | 0.35 | 4.76 | 3.17 |
| 240 | 92.8 | 93.3 | 0.17 | 0.14 | 0.72 | 0.77 | 3.98 | 4.25 | 0.38 | 0.33 | 2.90 | 2.14 |
| Lsd (0.05) | 5.9 | 4.7 | 0.09 | 0.11 | 0.05 | 0.06 | 0.55 | 0.43 | 0.03 | 0.05 | 3.66 | 4.75 |

## Discussion

Agege 1 variety of sweet orange could be classified as a seedy cultivar having more than 15 seeds. The increase in TSS with fruit maturity could be attributed to sugar accumulation in the pulp as high amounts of soluble carbohydrates are translocated to the developing fruits as supported by Iglesias *et al*(2001). TSS is an important maturity index for citrus that contributes to flavor and determines consumers' acceptability. Titratable acidity on the other hand decreased with fruit maturity in both season due to catabolism of the citric acid. It is important that acidity in fruit is reduced. Increasing pH may be due to decrease in the acidity of the fruit with maturity. Carbohydrates decreased because starch disappears with fruit maturity. The peel colour of the sweet orange fruits remained green probably because the orange was cultivated in tropical humid region. According to Ladaniya (2008), changes in the peel colour of sweet orange on the tree are due to the weather condition. A high temperature was experienced during fruiting which reduced the rate of chlorophyll degradation and the fruit remained green even with increasing maturity.

## Conclusion

The physical, biochemical and proximate composition of sweet orange (cv. Agege 1) changed with fruit maturity in the organic production system. However, the peel colour of the fruits remained green with maturiy.

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