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# Nutritive Content and Proximate Composition of Tomato (*Lycopersicon esculentum* Mill) Fruits with Organic and Inorganic Fertilizer and Harvest Maturity Index

**MT Ogunleye[1*], JG Bodunde[1], EA Makinde[1], OP Sobukola[2] and BA Shobo[3]**

[1]*Department of Horticulture, Federal University of Agriculture Abeokuta, Ogun State, Nigeria*
[2]*Department of Food Science and Technology, Federal University of Agriculture Abeokuta, Ogun State, Nigeria*
[3]*Department of Agriculture and Industrial Technology, Babcock University, Ilishan, Ogun State, Nigeria*
[*]**Corresponding author:** MT Ogunleye, Department of Horticulture, Federal University of Agriculture Abeokuta, Ogun State, Nigeria, E-mail: ogunleyemt@gmail.com

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## Abstract

*Tomato (Lycopersicon esculentum Mill) is a nutritive perishable fruit with short shelf-life. Tomato fruits used were harvested from plants imposed with NPK 15:15:15 (300 kg/ha), Poultry manure (20 t/ha) and no fertilizer application which served as control from the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta, Nigeria (FUNAAB). Prior to planting, soil and poultry manure samples were analyzed to ascertain the available nutrient present. Also, the meteorological data were obtained from the Department of Water Resources Management, FUNAAB, to examine the effect of weather condition on the produce quality. The fruits were transferred to the laboratory to commence the postharvest studies at the laboratory of the Department of Horticulture, FUNAAB, between 2014 and 2015 to evaluate the effects of fertilizer type and harvest maturity index on the nutritive and proximate composition of the fruits. Fruits from poultry manure plots had the highest ß carotene and TSS content while fruits from unfertilized plots had the highest lycopene contents, Vitamin C and pH. Fruits harvested at breaker stage had the highest pH and Vitamin C content; those at turning stage had the highest ß-carotene and TSS while those at full ripe stage had the highest lycopene content.*

**Keywords:** *Lycopersicon esculentum*; Vitamin C; Lycopene; Total soluble solids; Crude fibre; Harvest maturity stage

## Introduction

Tomato is one of the most important commercial vegetables grown in the tropics but due to the continuous degradation of the soil as resulted in the risk of food security. It is rich in vitamins, minerals and lycopene, an excellent antioxidant that helps reduce the risk of prostate and breast cancer. In the quest to improve soil fertility, use of inorganic fertilizers was adopted but this has not been helpful in intensive agriculture. Consequently, the need for the use of an alternative which would be affordable and available arose. This has led to the use of organic fertilizers worldwide recommended 20 t $ha^{-1}$ poultry manure for tomato production in the rainforest zone of southwest Nigeria. Also reported 20 t $ha^{-1}$ poultry manure to give the highest tomato yield in the rainforest region of southwestern Nigeria [1].

The current population of Nigeria cannot depend solely on the use of renewable energy, so the use of inorganic fertilizer is inevitable especially for a crop like tomato which has a high nitrogen demand. An abuse can however lead to great losses, resulting in susceptibility of fruits to decay, mechanical injury, physiological disorder, decrease in

sugar content, firmness a drastic effect on fruit skin colour and cuticle thickness. It is important for fruits to be picked at the appropriate time as delayed harvesting results in high post-harvest losses. When picked before completing its physiological development, it can result in undesirable colouration. The use of fertilizers and proper harvest maturity index contribute to reduction in food losses and protection of the nutritive quality of tomato fruit. This experiment was conducted to investigate the influence of fertilizer and harvest maturity index on the proximate and biochemical contents of tomato fruit [2].

## Materials and Methods

The fruits were obtained from the Directorate of University Farms, Federal University of Agriculture, Abeokuta, a derived savannah in the tropics. The nursery activity lasted for four weeks after which the seedlings were transplanted to the field. Samples of the poultry manure and soil were analyzed at the Department of Soil Science laboratory, Federal University of Agriculture Abeokuta to determine the amount of nutrients present prior to transplanting. The plots were introduced to three types of fertilizer; poultry manure (20 t/ha) incorporated two weeks before transplanting, NPK 15:15:15 (300 kg/ha) was incorporated two weeks after transplanting and plots with no fertilizer application which served as the control [3].

After eight weeks, fruits were harvested and transferred to the laboratory for postharvest studies. The postharvest study was conducted in the laboratory of the Department of Horticulture, Federal University of Agriculture, Abeokuta, Nigeria in 2014 and 2015. Fruits produced with poultry manure (20 t/ha); NPK 15:15:15 (300 kg/ha); and an unfertilized control were harvested at three maturity indices: Breaker stage, turning stage and the full ripe stage. The breaker stage was a stage where there was a definite break in colour, usually less than 10 percent of the fruit surface; the turning stage was when there was a definite change in colour from green to orange, covering about 10%-29% of the fruit surface while full ripe stage was when the fruit showed complete change in colour from green to red, covering over 90 percent of the fruit.

The metrological data was obtained from the department of Water Resources Management to have a concise knowledge of the weather activity during the course of the experiment. The experiment was laid out in a Completely Randomized Design (CRD) with three replications [4].

### Data collection

Proximate analysis was obtained using AOAC, 1990, determination of Total Soluble Solids (TSS) and Vitamin C using DCPIP dye was obtained using the procedure of Determination of Lycopene content was obtained using the procedure of. Tomato fruits grown with the three fertilizer types and harvested at the three harvest maturity indices were used for the analysis [5].

### Statistical analysis

Data collected were subjected to Analysis of Variance (ANOVA) using GenStat Discovery Edition 12. Means were separated using Standard Error (SE) at 5% probability.

## Results

### Physical and chemical properties of soil and poultry manure of experimental site in 2014 and 2015

The soil used for the experiment was sandy loam in texture, and slightly acidic, with high level Phosphorus (P) in 2014 and 2015, moderate organic matter content and low level Nitrogen (N) and Potassium (K). The poultry manure used for the experiment was alkaline in nature with high amount of Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) (Table 1).

**Table 1:** Physical and chemical properties of soil and poultry manure of experimental site in 2014 and 2015.

| Parameter | Soil | | Poultry manure | |
|---|---|---|---|---|
| | 2014 | 2015 | 2014 | 2015 |
| pH | 6.5 | 6.5 | 9.4 | 8.9 |
| Organic matter (%) | 5.11 | 5.39 | 2.41 | 2.34 |

| | | | | |
|---|---|---|---|---|
| Total nitrogen (%) | 0.21 | 0.26 | 0.18 | 0.38 |
| Available P (ppm) | 40 | 40.29 | 8.86 | 8.1 |
| Exchangeable Ca (mg/kg) | 0.22 | 0.28 | 53.59 | 52.62 |
| K (ppm) | 0.7 | 0.81 | 0.4 | 0.68 |
| Mg (me/100 g) | 4.65 | 4.67 | 12.26 | 10.18 |
| Na (me/100 g) | 0.75 | 0.85 | 25 | 21.75 |
| ECEC (me/100 g) | 20 | 26.49 | - | - |
| Fe (mg/kg) | 11.31 | 11.2 | 23.25 | 24.42 |
| Zn (mg/kg) | 1.34 | 1.61 | 3.8 | 3.6 |
| Cu (mg/kg) | 0.18 | 0.45 | 0.33 | 0.45 |
| Particle size | - | - | - | - |
| Sand (g/kg) | 770 | 810 | - | - |
| Clay (g/kg) | 2020 | 1890 | - | - |
| Silt (g/kg) | 180 | 110 | - | - |
| Textural class | Sandy loam | Sandy loam | - | - |

**Agro-meteorology weather report for the two years**

The highest rainfall observed during the field trial was in June in 2014 (116.5 mm) and 2015 (164.9 mm). Sun shine duration was at its peak in December 2014 (6.5 hr) and January 2015 (6.1 hr) during the period of the experiment. Maximum temperature was experienced in December 2014 (34.6°C) and January 2015 (35.4°C) (Table 2).

**Table 2:** Meteorological data during the period of the experiment in 2014 and 2015.

| Month | Rainfall (mm) | | Sunshine (hr) | | Maximum Temperature (°C) | | Minimum Temperature (°C) | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| June | 116.5 | 164.9 | 5.9 | 4.2 | 31.5 | 30.8 | 23.4 | 22.8 |
| July | 90.7 | 65.6 | 3.8 | 3.4 | 29.9 | 31.5 | 23.3 | 22.8 |
| August | 92.7 | 29.4 | 2.3 | 2.3 | 29.1 | 29.5 | 22.1 | 22.8 |
| September | 165.1 | 71.1 | 3.2 | 2.8 | 29.8 | 30.4 | 22.7 | 22.5 |
| October | 159.1 | 70.2 | 5.3 | 5.9 | 30.5 | 31.6 | 22 | 23 |
| November | 16.6 | 67.3 | 5.3 | 6.3 | 32.4 | 33.5 | 22.6 | 23.8 |
| December | 0 | 56.7 | 6.5 | 5.1 | 34.6 | 33.5 | 21.8 | 19.3 |

**Influence of fertilizer type on ash, moisture content, crude fibre and crude protein contents of tomato fruits harvested in 2014 and 2015**

Ash content was generally higher in 2015, relative to 2014. The highest was from fruits the unfertilized plots but were comparable with those from the fertilized plots (Figure 1). The Crude fibre had the same trend as ash content. Moisture content was highest with fruits from NPK fertilized plants but was also comparable with fruits from Poultry manure treatment and from the unfertilized plots [6].

Crude protein was higher in 2015, relative to contents in 2014, with the unfertilized plants having the highest contents which were comparable with fruits from the fertilized plots (Figures 1-4).

**Figure 1:** Influence of fertilizer type on ash, moisture content, crude fibre and crude protein contents on tomato fruits harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Ash (high).

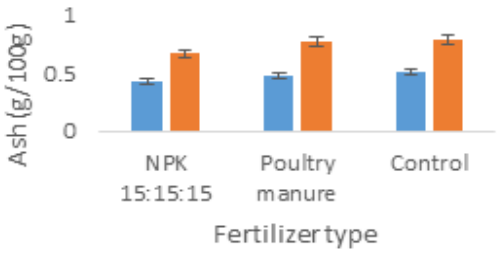



**Figure 2:** Influence of fertilizer type on moisture content, contents on tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (High); : Moisture content (Low).

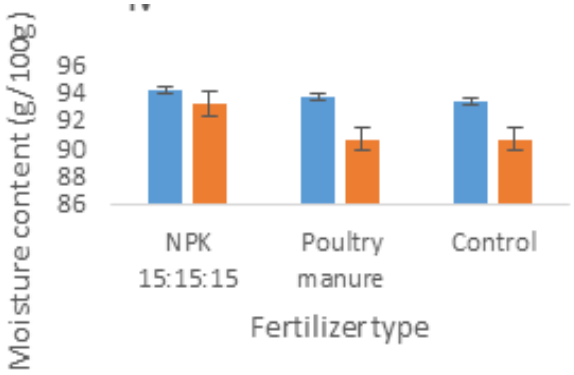



**Figure 3:** Influence of fertilizer type on crude fibre, contents on tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (Low); : Crude fibre (High).

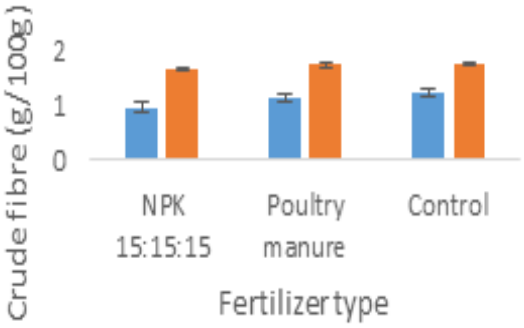
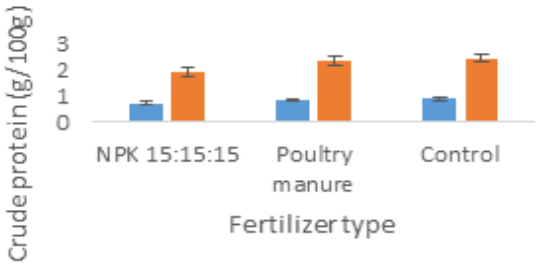



**Figure 4:** Influence of fertilizer type on crude protein, contents on tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (Low); : Crude protein (High).



**Influence of fertilizer type on lycopene, total soluble solid vitamin C contents and pH on tomato of tomato fruits harvested in 2014 and 2015**

Lycopene content was highest in fruits from the unfertilized plants in 2014 but from NPK fertilized plants in 2015. They were generally higher in 2015 relative to 2014 (Figure 5). Total soluble solid was highest from the poultry manure treatment in 2014. In 2015, it was similar in the fruits from both fertilized plots and the control. Vitamin C content was highest from the unfertilized plants in 2014 and least from the NPK fertilized plants. In 2015, the NPK fertilized plants had the highest content when fruits from poultry manure treatment and the unfertilized plants had the same but lower contents [7]. pH of fruits in 2014 from the unfertilized plants were most acidic while fruits from the fertilized plots had higher pH. In 2015, the lowest pH was from poultry manure fertilized plants while NPK fertilized plants had fruits with the highest pH (Figures 5-8).

**Figure 5:** Influence of fertilizer type on lycopene, total soluble solid vitamin c contents and pH on tomato of tomato fruits harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Lycopene (High).

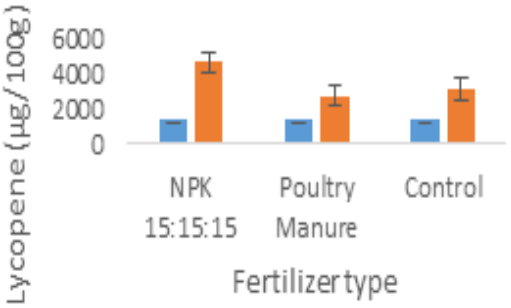



**Figure 6:** Influence of fertilizer type on total soluble solid, tomato of tomato fruits harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Total soluble solid (High).

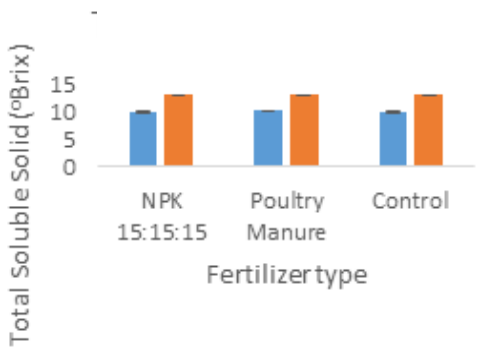



**Figure 7:** influence of fertilizer type on pH, tomato of tomato fruits harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Ph (High).

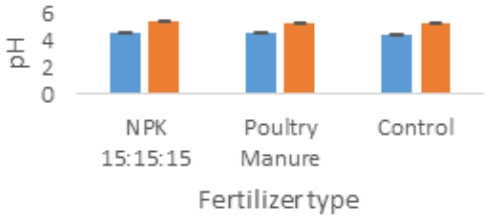
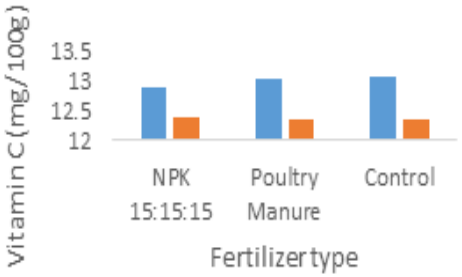


**Figure 8:** Influence of fertilizer type on vitamin C, tomato of tomato fruits harvested in 2014 and 2015. **Note:** ■ : Fertilizer (High); ■ : Vitamin C (Low).




**Influence of harvest maturity index on ash, moisture content, crude fibre and crude protein content of tomato fruits harvested in 2014 and 2015**

Ash content was generally higher in 2015, relative to 2014. The highest was from fruits harvested at turning stage which were comparable with contents of fruits harvested at other harvest maturity index (Figure 3). Fruit moisture content was higher in 2014 than 2015. This could be as a result of the amount of rainfall received by the plant in 2014 while in the field, the plants received a total of 348.5 mm in 2014 compared to 161.1 mm in 2015 [8]. Fruits harvested at full ripe stage had the highest moisture content in 2014 in both years. Crude fibre was higher in 2015 relative to contents in 2014, with fruits harvested at breaker stage having the highest contents which were comparable with fruits from harvested from other harvest maturity index (Figure 3). Crude protein was higher in 2015, relative to contents in 2014, with fruits harvested at turning stage having the highest contents which were similar to fruits from harvested from other harvest maturity index (Figures 9-12).

**Figure 9:** Influence of harvest maturity index on ash, moisture content, crude fibre and crude protein content of tomato fruits harvested in 2014 and 2015. **Note:** ■ : Fertilizer (Low); ■ : Ash (High).


**Figure 10:** Influence of harvest maturity index on moisture content, content of tomato fruits harvested in 2014 and 2015. **Note:** ■ : Fertilizer (High); ■ : Moisture content (Low).

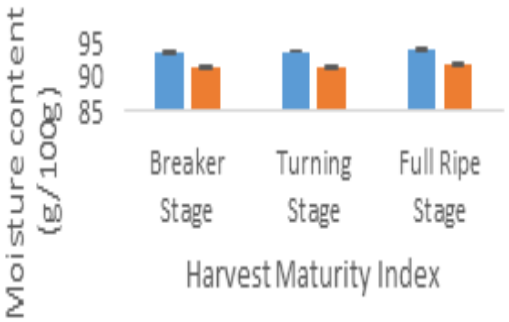


**Figure 11:** Influence of Harvest Maturity Index on Crude Fibre, Content of Tomato Fruits Harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Crude fibre (High).

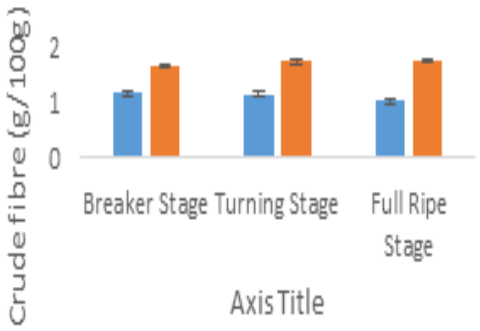
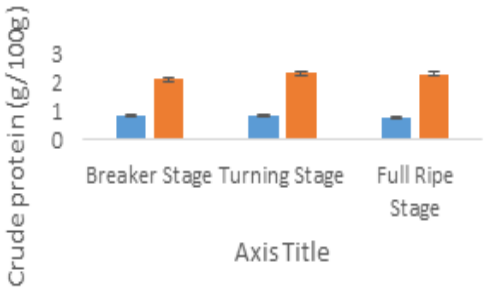



**Figure 12:** Influence of harvest maturity index on crude protein, content of tomato fruits harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Crude protein (High).




**Influence of harvest maturity index on lycopene, TSS, vitamin C contents and pH content of tomato fruits harvested in 2014 and 2015**

Lycopene content was higher in 2015 relative to contents in 2014, with fruits harvested at full ripe stage having the highest contents which were comparable with fruits from harvested from other harvest maturity index. Total Soluble Solid was higher in 2015 relative to contents in 2014, with fruits harvested at turning stage having the highest contents which were similar to fruits from harvested from other harvest maturity index [9]. Vitamin C content was generally higher in 2014, relative to 2015. The highest was from fruits harvested at breaker stage but were comparable with contents harvested from other harvest maturity index. pH of fruits harvested at turning stage in 2014 was most acidic. Fruits from the other harvest maturity index also had low pH. In 2015, the lowest pH was from fruits harvested at breaker stage while fruits harvested at turning and full ripe stages had the highest pH (Figures 13-16).

**Figure 13:** Influence of Harvest Maturity Index on Lycopene, TSS, Vitamin C Contents and pH on Tomato Fruits Harvested in 2014 and 2015. **Note:** : Fertilizer (Low); : Lycopene (High).

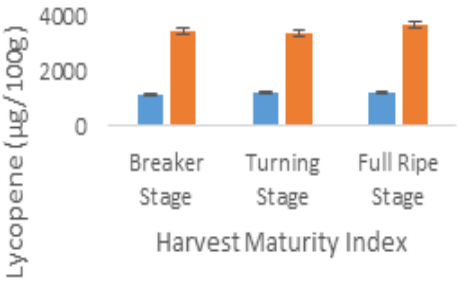


**Figure 14:** Influence of harvest maturity index on total soluble solid, tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (Low); : Total soluble solid (High).

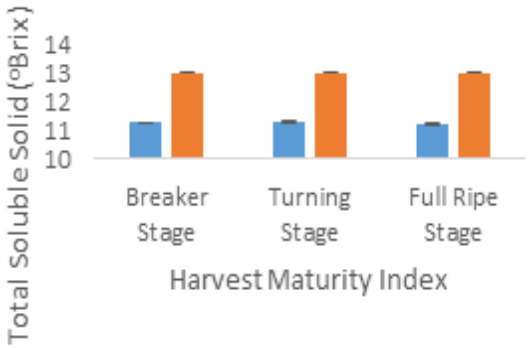



**Figure 15:** Influence of harvest maturity index on vitamin C, tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (High); : Vitamin C (Low).

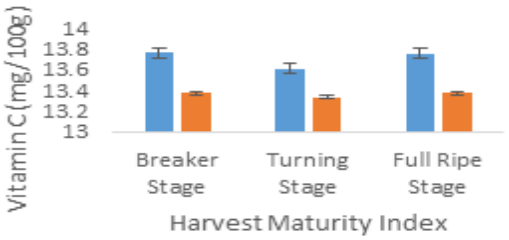
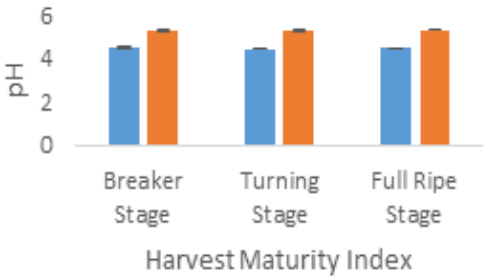



**Figure 16:** Influence of harvest maturity index on pH, tomato fruits harvested in 2014 and 2015.
**Note:** : Fertilizer (Low); : PH (High).




**Discussion**

The soil is rich in phosphorus which aids in photosynthesis, respiration, energy storage and transfer. This explains why the fruits were properly formed. The soil was also high in potassium which aided in regulating metabolic activities. Finally, the calcium and magnesium content of the soil was high which could have been responsible for the firm pectic cell wall of the tomato fruits [10]. At establishment, the tomato plant received a generous quantity of rainfall of 116.5 mm in 2014 and 164.9 mm in 2015. However, observing the total amount of rainfall received, tomato received 299.9 mm of rainfall in 2014 while in 2015, 259.9 mm rainfall was received. This might explain why the moisture content of the tomato fruits harvested in 2014 is higher than those harvested in 2015 [11,12].

The ash content present in the fruit was from 0.42 g/100 g-0.78 g/100 g independent of the fertilizer applied which was in line with who stated that the ash content of Roma VF should range from 0.47%-0.98% and who recorded an ash content of 0.46%. Fruits grown in 2014 had more moisture content than those harvested in 2015. This could be as a result of the rains received while on the field [13,14]. Also, fruits cultivated using N P K 15:15:15 had more

moisture which could be as a result of high phosphorus in the fertilizer. However, stated that Roma VF fruits should contain a moisture content of 89.40% ± 0.10% while stated 91.91% compared to 94.12 g/100 g which was observed from the tomato fruit analysed. Fruits imposed with N P K 15:15:15 had the lowest crude fibre content. This could be because of the sufficient nutrient present in the soil.

Hence, the addition of extra nutrient had a detrimental impact on the crude fibre content. Stated that Roma VF has a crude fibre content of 1.77% ± 0.09% which was contrary to the 94.12 g/100 g-90.63 g/100 g in this case. The crude protein in the fruit was recorded to have a range of 0.72 g/100 g-2.43 g/100 g which was in line with who recorded a crude protein level of 1.30% ± 0.06%. Stated that Roma VF should contain 12.47 µg/100 g lycopene content which was contrary to 1200 µg/100 g in this trial. The total soluble solid content of tomato fruit in this experiment was 9.87-13 $^{o}$Brix this is contrary to 4.23-5.22 $^{o}$Brix stated. The range of pH of the tomato fruit was between 5.39-4.47 which was in line with that stated that the tomato pH should be between 4.72-3.96.

**Conclusion**

Stated that Roma VF should contain a vitamin C content of 23.27 µg/100 g ± 0.6 µg/100 g compared to the 0.37 µg/100 g ± 0.05 µg/100 g which was observed in this trial. In 2015, fruits harvested at all harvest maturity index had higher ash, moisture, crude fibre and crude protein content compared to those harvested in 2014. This could be because of the sufficient sun light and rain received by the fruits while still on the field. Fruits harvested in 2015 had higher Lycopene, TSS and pH irrespective of the harvest maturity. This could be due to favouarble weather condition. However, in 2014 fruits harvested had high Vitamin C irrespective of the maturity stage.

The observation that fruits grown without fertilizer had the highest value of proximate components could be because the available nutrient present in the soil probably sufficed the nutrient content necessary for the growth and development of the tomato. However, an addition of more nutrient either in organic or inorganic form, may have fixed some available nutrient resulting in low tomato fruit nutrient for fruits harvested with plots fortified with nutrients. Finally, weather character and harvest maturity indices influences the proximate and nutritive content of the tomato fruits. In this experiment, fruits harvested at full ripe stage had higher nutritive component value than other maturity stages.

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