Engineering and Technology Journal e-ISSN: 2456-3358

Volume 09 Issue 08 August-2024, Page No.- 4926-4934

DOI: 10.47191/etj/v9i08.43, I.F. – 8.227

Characterization of the "armored" Tomato from the Adamawa-Cameroon Region for Preservation Purpose

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ABSTRACT: Tomatoes are one of the most perishable fruits and vegetables and have a short shelf life. A large part of the tomatoes is lost after harvest. The so-called "armored" tomatoes grown in Adamaoua-Cameroon are no exception. Losses occur in harvesting, transport and storage. It is becoming urgent to design devices to solve this problem. In order to properly size these devices, we carried out a characterization of the ambient air and it was concluded that the ambient conditions were unfavorable for the preservation of these fruits. Then we made a characterization of the shape, diameter, length, mass and volume of this fruit. We found that the mean diameter is 3.58 cm, the standard deviation of the diameter set is 0.5 cm, the mean length 6.6 cm, the standard deviation of the length set is 0.84 cm, the mean side surface is 86.6 cm^2, the standard deviation of the side surface set is 23.9 cm^2, the mean mass of a fruit is 79.2g, the standard deviation of the mass set is 16.19g, the mean volume is 60.2 cm^3 and the standard deviation of the volume set is 23.87 cm^3. Subsequently, we measured the water content of samples of this fruit at different stages of ripening. It turned out that the water content of a tomato sample increases as it ripens. We also studied the colorimetric evolution of samples of "armored" tomatoes harvested when green ripe. We found that the samples did not ripen at the same speed. Some took 5 days while others took up to 7 days to reach red ripeness. After 8 days, it was observed that 12 samples were ripe and in good condition, so 44.8%.

KEYWORDS: Equipment design; Morphological characterization; Preservation; Shelf life; Tomatoes.

1. INTRODUCTION

Tomato (Solanum lycopersicum or Lycopersicon esculentum) is one of the most important and popular fruits vegetables produced both in the world **[1],[2]** and in Cameroon. It is a self-pollinated annual crop and belongs to the family Solanaceae with chromosome number 2n = 2x = 24 **[3],[4],[2]**.These fruits have a short shelf life. The shelf life is a period of time which starts from harvesting and extends up to the start of rotting of fruits **[5],[6]**. Postharvest losses in tomatoes can be as high as 42% globally. Postharvest losses in tomatoes can be either quantitative or qualitative **[7].** To provide an appropriate solution to the problem of post-harvest loss of tomato fruits, it is important to make a precise characterization of these fruits. It discusses some of its morphological, physical, chemical and physicochemical properties. This, with the aim of finding a sufficiently simple geometric shape for the design of the cells or handling bins, finding the volume occupied by a tomato for sizing the preservation enclosure, finding the surface area for heat transfer, determining the relative humidity of air suitable for mass transfer, determine the mass to estimate the amount of energy required for transport or movement.

2. OBJECTIVES

- Determine the geometric shape of the tomato
- Determine the water content of the tomato
- Determine the mean mass of tomatoes
- Determine the colour of the tomato at each stage of maturity

3. MATERIALS AND METHODS

3.1. Materials

- **Plant material**
  - 04 Armored tomatoes when green ripe
  - 05 Semi-ripe tomatoes
  - 03 Red ripe tomatoes
- **Laboratory equipment**
  - Précisa brand precision balance (Max 2200g d=0.1g Min 0.5g d=0.01g) SWISS made
  - TOTAL brand electronic calliper
  - Emmert brand oven from France corporation
  - Desiccator (unbranded)

- Crucible (aluminium box made from Malta boxes)
- Utensil: 35 cm kitchen knife (unbranded) with blue plastic handle
- Thermohydrometer

3.2. Methods

3.2.1. Measurement of temperature, relative humidity and ambient air pressure

We measured the temperature, relative humidity and pressure of the ambient air for three days. This is with the aim of comparing the values of these parameters to the adequate values for preserving tomato fruits. The optimal values of relative humidity for mature green tomatoes are within the range of 85–95% (v/v) but 90–95% (v/v) for firmer ripe fruits **[8]**. Proper temperature management between the period of harvesting and consumption has been found to be the most effective way to maintain quality. Keeping harvested fruits cool at low temperatures of about 20∘C will slow down many metabolic activities which lead to ripening, hence allowing more time for all the postharvest handling of the produce. Generally, one hour of delay between harvesting the crop and cooling it will lead to one day loss of shelf life **[9]**,**[10]**.

We placed a recording temperature and relative humidity datalogger in the open air for three days.

Cylindrical and Ellipsoid fruit were also recorded among the genotypes. **[11]** also reported diverse fruit shape such as flattened, slightly flattened, cylindrical, rounded, high-rounded, and heart-shaped

3.2.2. Sample preparation

The maturity stage of tomato fruit at harvest is an important determinant of many quality traits **[12]**. Tomato, being a climacteric fruit, can be harvested at different stages during maturity, like mature green, half ripen, or red ripen stage. Each stage at harvest has its own postharvest attribute that the fruit will exhibit**. [13]** reported that the shelf life of all tomato cultivars under investigation is longest when harvested at green mature stage. Although shelf life has been the most important aspect in loss reduction biotechnology of fruit and vegetables, other aspects may be of interest rather than shelf life **[7].**

- We harvested healthy tomatoes this morning, 10/07/24 at 10 a.m., of different levels of maturity
- We washed them, labelled them.

Figure 1: Image of labeled tomatoes samples and their corresponding colors

3.2.3 Weighing of each sample

Figure 2: Weighing of each sample

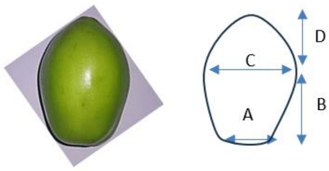


Figure 3: Geometric drawing of a tomato

Figure 4: Measurements with the caliper

Fruit shape and size is so important not only for the consumer but also for the transportation. Fruit shape is one of the most promising traits which can be visualized by naked eye and can be utilized for clear cut identification of tomato cultivars during field inspection **[2]**.

The surface area of the disk with diameter A is given by the formula

$$s_1 = \frac{\pi A^2}{4} \tag{1}$$

The surface area of the disk with diameter C is given by the formula

$$s_2 = \frac{\pi C^2}{4} \tag{2}$$

The cone surface of height D is given by the formula

$$s_3 = (\sqrt{C^2 + D^2})\pi C \tag{3}$$

The side surface of the cylinder of height B is given by the formula

$$s_4 = \pi CB \tag{4}$$

The volume of the cylinder of height B is given by the formula

$$v_1 = \frac{1}{4}\pi C^2 B \tag{5}$$

The volume of the cone of height D is given by the formula

$$v_2 = \frac{1}{12}\pi C^2 D \tag{6}$$

The total surface area of the tomato is given by the formula

$$S = s_3 + s_4 \tag{7}$$

The total volume of the tomato is given by the formula

$$V = v_1 + v_2 \tag{8}$$

The total length of the tomato is given by the formula

$$L = B + D \tag{9}$$

3.2.5 Measuring the water content of ‘armored’ tomatoes

Figure 5: Samples retained for measuring water content

Each of these tomatoes was divided into three slices along the longest central axis of symmetry so that each part had the same composition as the whole starting tomato.

Figure 6: Sliced and labeled samples

- Each slice has been labelled as follows:
  - T4 - Slice 1 : T41, Slice 2 : T42 and Slice 3 : T43
  - T7 - Slice 1 : T71, Slice 2 : T72 and Slice 3 : T73
  - T12 - Slice 1 : T121, Slice 2 : T122 and Slice 3 : T123
- Each slice (sample) was weighed to determine the wet masses (Mw) then placed in an oven at a temperature of 105°C at 3:10 p.m.

Figure 7: Weighing sample slices

Figure 8: Samples in the oven

The next day, at 3:10 p.m., each sample was removed from the oven, placed in a desiccator and weighed again to determine the dry masses (Md).

- **Figure 9: Dried samples taken out of the oven and placed in a desiccator**

Figure 10: Dried samples removed from the desiccator and ready for weighing

We finally calculated the water content of each slice by the formula

$$W = ((M\_w - M\_d))/M\_w \times 100 \qquad (10)$$

4 COLORIMETRIC STUDY

We collected 29 samples of green ripe tomatoes. We examined them and placed them in the open air in a clean space. Images of the samples were taken twice a day for 7

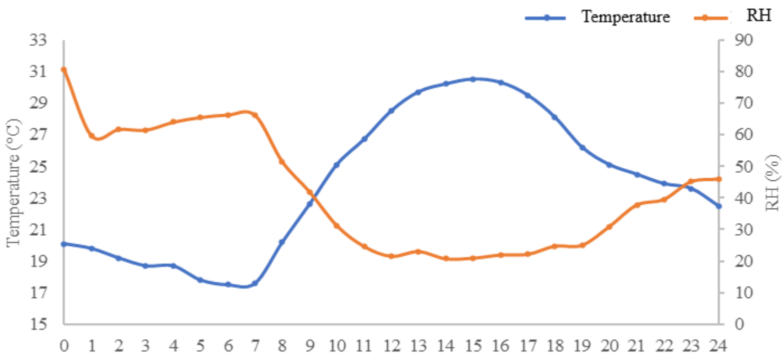
Mean pressure of day 3: 1006, 375 hPa

days to observe the evolution of the colorimetry. A temperature and relative humidity datalogger was placed near the samples for measurements.

5 RESULTS AND DISCUSSION

5.1 Measurement of temperature, relative humidity and ambient air pressure

The results of these measurements are presented in the graphs of Figures 11, 12 and 13



Mean pressure of day 1: 1005, 75 hPa

Figure 11: **Evolution of temperature and Relative Humidity of day 1**

Mean pressure of day 2: 1005,37 5hPa

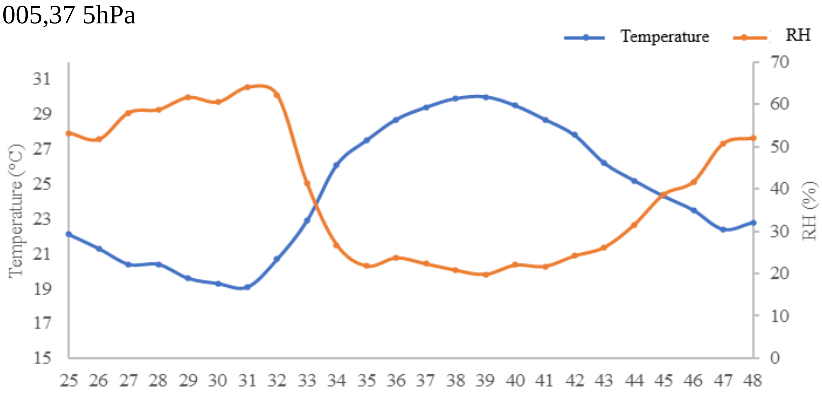


Figure 12: Evolution of temperature and Relative Humidity of day 2

On Figure 11, 12 and 13, we observe that temperature values vary in the range of 19 to 34 °C and RH values, between 21 and 80% during these three days.

The following three questions should be answered for each day of observation.

From what time does we have T (°C) between 17 and 21?

- day 1: from 00 to 07 a.m.
- Day 2: from 1 a.m. to 7 a.m.
- Day 3: from 1 a.m. to 7 a.m.

What duration?

- day 1: 7 hours
- Day 2: 6 hours

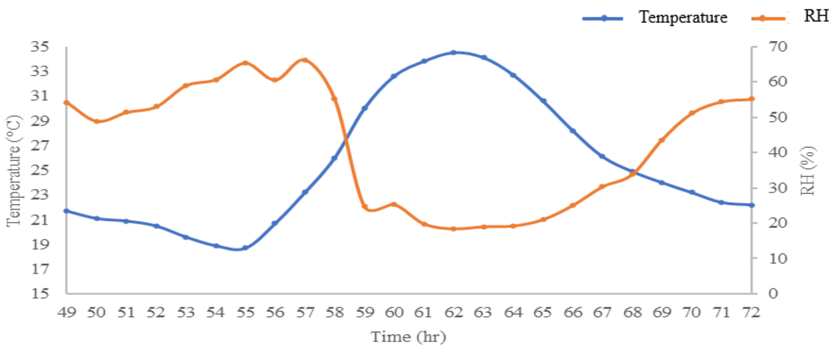


Figure 13: Evolution of temperature and Relative Humidity of day 3

- Day 3: 6 hours

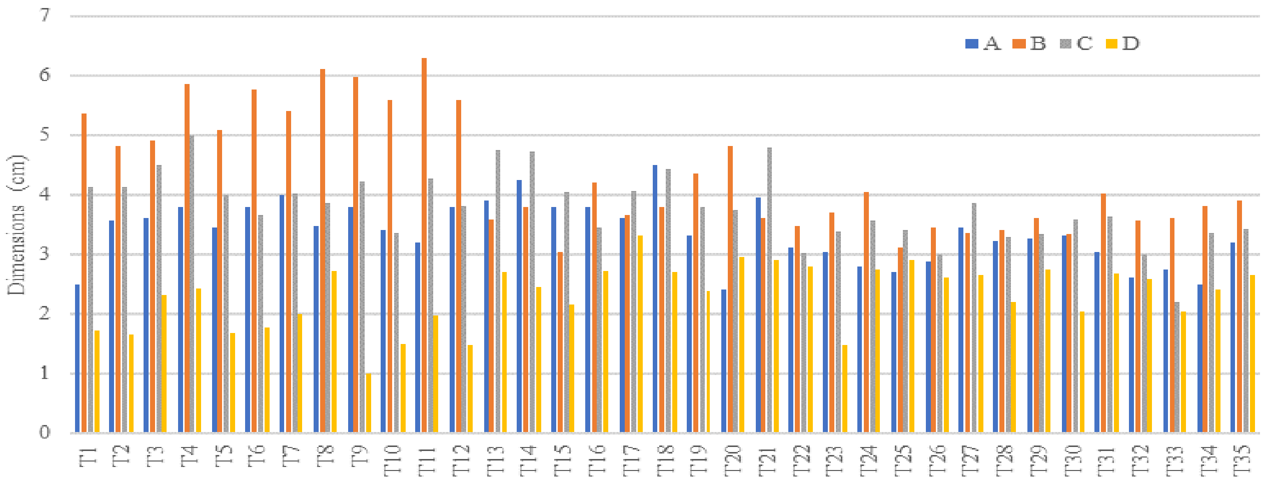


Figure 14: Dimensions A, B, C and D of each sample

What percentage over the 24 hours of observation?

- day 1: 29.16%
- Day 2: 25%
- Day 3: 25%.

Conclusion: The ambient air that we have characterized is not conducive to the preservation of “armored” tomato fruits.

5.2 Morphological characterization of fruits

The results of this study are presented in the following figures 14.

T20 is the sample that has the smallest A = 2.4 cm and T18 is the sample that has the largest A = 4.5 cm. The mean of A is 3.36 cm and the standard deviation of A is 0.52 cm.

T15 is the sample that has the smallest B= 3.05 cm and T11 is the sample that has the largest B = 6.29 cm. The mean of B is 4.34 cm and the standard deviation of B is 0.99 cm.

T33 is the sample that has the smallest C= 2.2 cm and T4 is the sample that has the largest C = 5 cm. The mean of C is 3.80 cm and the standard deviation of C is 0.59 cm.

T9 is the sample that has the smallest D= 1 cm and T17 is the sample that has the largest D = 3.32 cm. The mean of D is 2.32 cm and the standard deviation of D is 0.53 cm.

We see that the samples do not have a uniform shape. It is shown in figure 15.

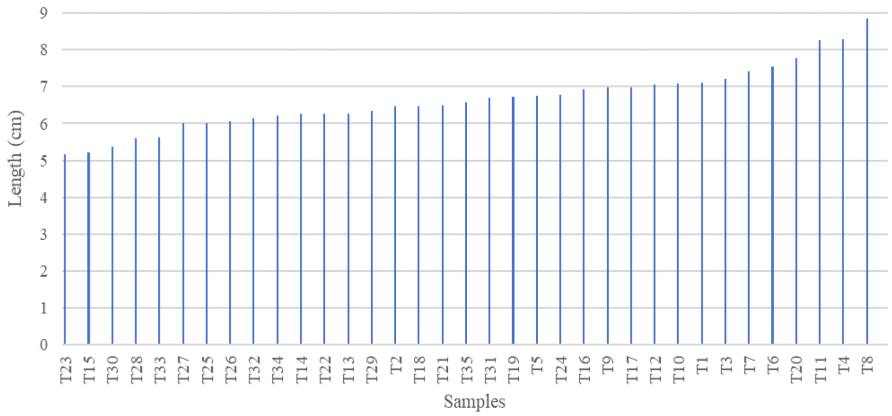


Figure 15: Length of samples

T23 has the shortest length with 5.18 cm and T8 is the longest sample with is 8.85 cm. The mean length 6.6 cm. The standard deviation of the length set is 0.84 cm

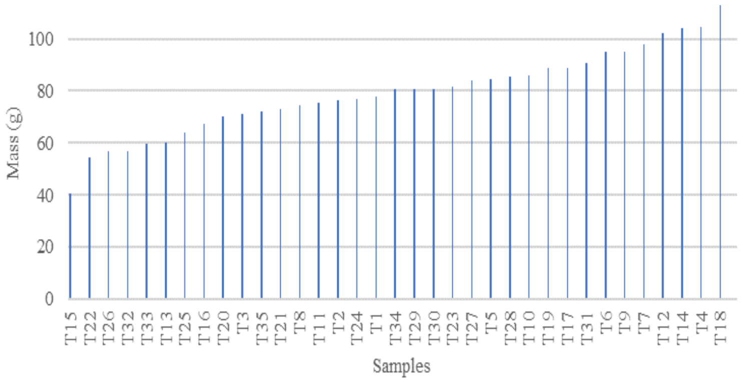


Figure 18: Mass of samples

T15 is the lightest sample with 40.7g and T18 is the heaviest sample with 114.8g. The mean mass is 79.2 g. The standard deviation of the mass set is 16.19g

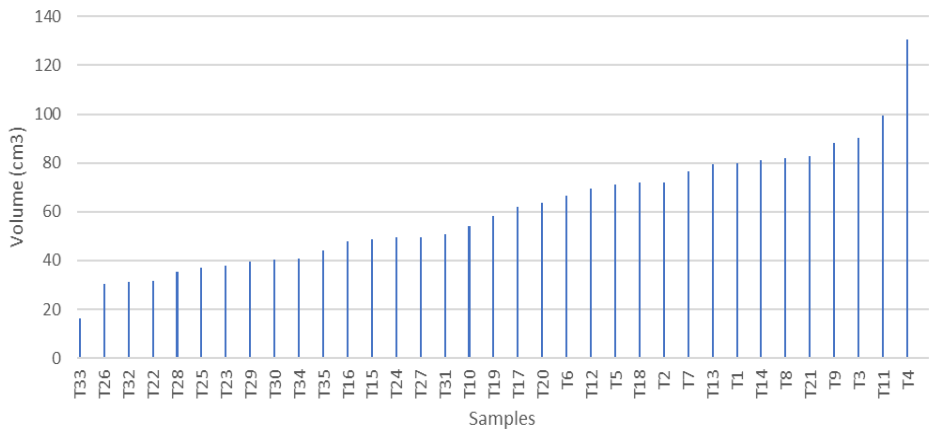


Figure 17: Volume of samples

T33 is the lowest volume sample with 16.3 cm^3 and T4 is the highest volume sample with 131 cm^3. The mean volume is 60.2 cm^3. The standard deviation of the volume set is 23.87 cm^3. The sample that has the greatest mass is not the one that has the large volume as one would expect. This would be due to the fact that the fruits do not have the same quantity of dry matter nor the same water content.

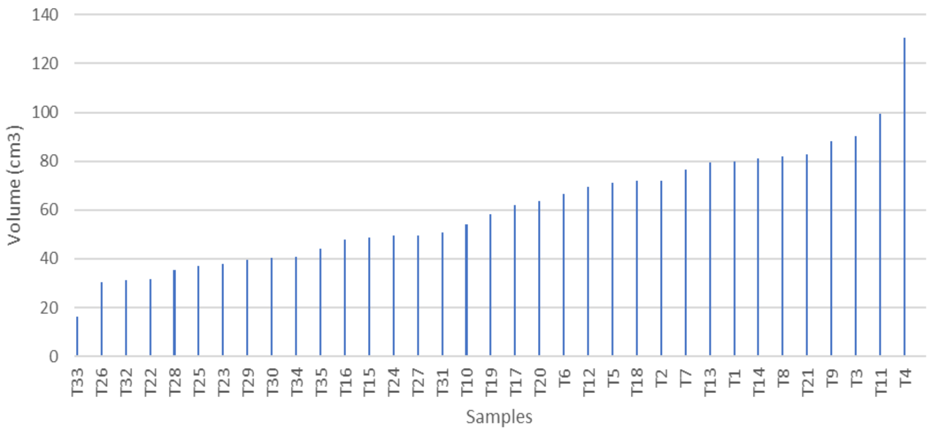


Figure 16: Side Surface of samples

T33 has the smallest lateral surface 44.6 cm^2 and T4 has the largest lateral surfac**e** with 141.7 cm^2. The mean side surface is 86.6 cm^2. The standard deviation of the side surface set is 23.9 cm^2.

Table 1: Summary of mean and standard deviations

	Mass (g)	Length (cm)	Diameter (cm)	Surface (cm^2)	Volume (cm^3)
Mean	79,24	6,66	3,58	86,61	60,28
Standard deviation	16,19	0,84	0,50	23,94	23,87

5.3 Water content of tomatoes

The values of this experiment are marked in the table which follows. Mw is the wet mass ant Md is the dry mass.

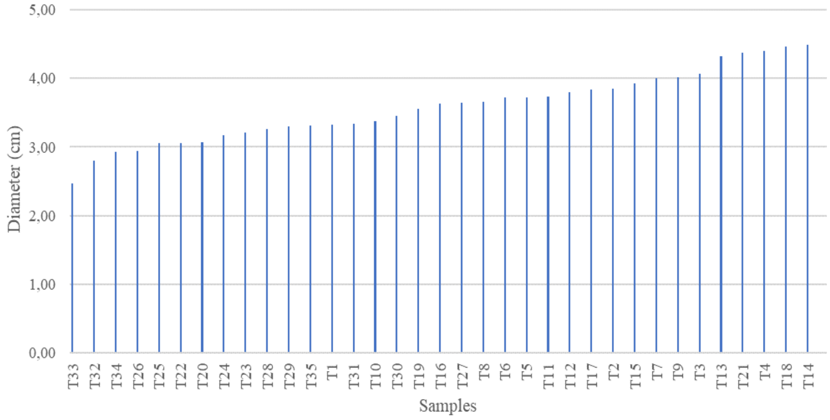


Figure 19: Diameter of samples

T33 is the sample with the smallest diameter with 2.47 cm and T14 is the sample with the largest diameter 4.40 cm. The mean diameter is 3.58 cm. The standard deviation of the diameter set is 0.5 cm.

Table 2: Water content of tomatoes

Samples of tomatoes	Slice	Mw (g)	Md(g)	W (%)
T4	T41	35.7	2.04	94.28
	T42	29.69	2.17	92.69
	T43	33.73	1.67	95.04
T7	T71	29.96	1.67	94.42
	T72	34.41	1.79	94.79
	T73	33.06	1.78	94.61
T12	T121	37.96	1.65	95.65
	T122	32.89	1.46	95.56
	T123	31.09	1.39	95.52

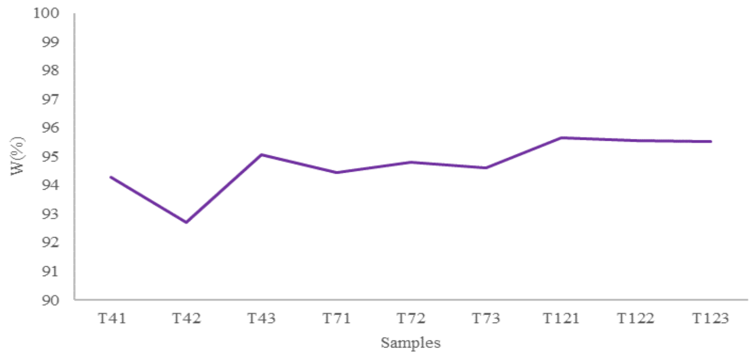
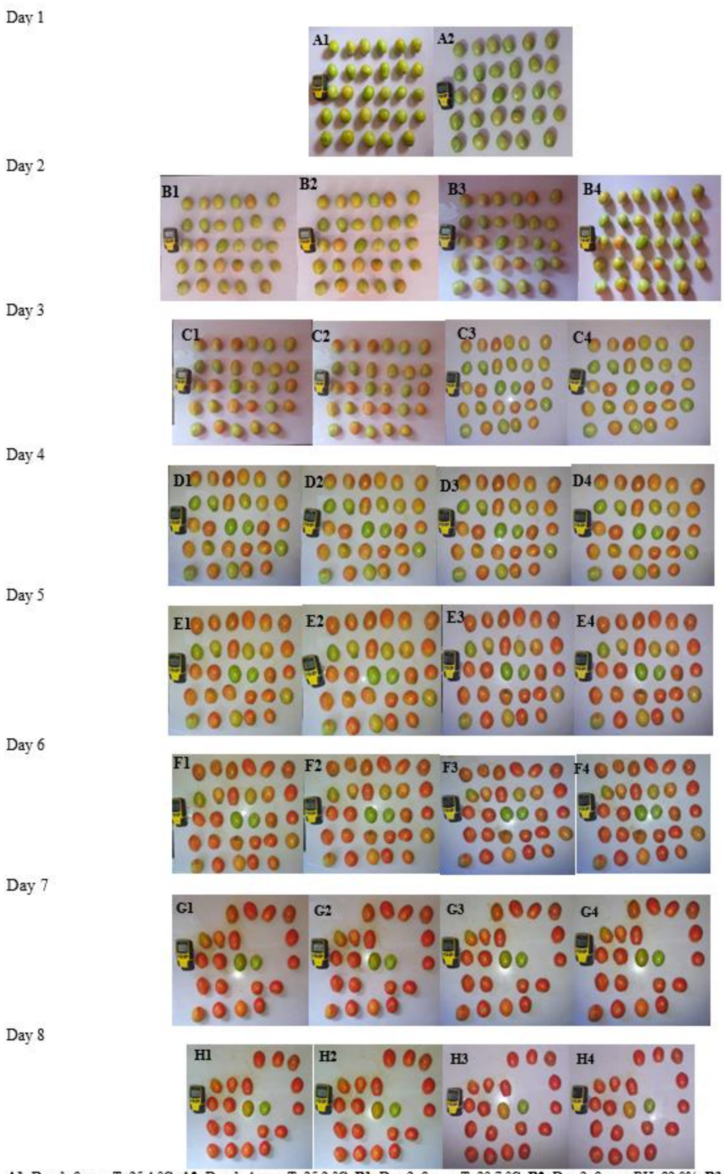


Figure 20: Water content of samples at 3 maturity phases

Generally speaking, W is between 94 and 96%. We notice that W increases with maturity and that for green tomatoes. W is not stable. it is not distributed fairly or uniformly in the total volume of the fruit.

5.4. Evolution of the colour of tomato samples

Images from this experiment are shown in Figure 21



A1: Day 1, 9 a.m, T: 25.4 °C; **A2**: Day 1, 4 p.m, T: 25.2 °C; **B1**: Day 2, 9 a.m, T: 23.7 °C; **B2**: Day 2, 9 a.m, RH: 82.0%; **B3**: Day 2, 4 p.m, T: 25.9 °C; **B4**: Day 2, 4 p.m, RH: 78.9%; **C1**: Day 3, 9 a.m, T: 23.8 °C; **C2**: Day 3, 9 a.m, RH: 82.8%; **C3**: Day 3, 4 p.m, T: 27.2 °C; **C4**: Day 3, 4 p.m, RH: 74.3%; **D1**: Day 4, 9 a.m, T: 23.6 °C; **D2**: Day 4, 9 a.m, RH: 80.5%; **D3**: Day 4, 4 p.m, T: 26.4 °C; **D4**: Day 4, 4 p.m, RH: 72.4%; **E1**: Day 5, 9 a.m, T: 24.0 °C; **E2**: Day 5, 9 a.m, RH: 82.3%; **E3**: Day 5, 4 p.m, T: 26.1 °C; **E4**: Day 5, 4 p.m, RH: 76.1%; **F1**: Day 6, 9 a.m, T: 24.3 °C; **F2**: Day 6, 9 a.m, RH: 80.7%; **F3**: Day 6, 4 p.m, T: 27.0 °C; **F4**: Day 6, 4 p.m, RH: 70.6%; **G1**: Day 7, 9 a.m, T: 23.8 °C; **G2**: Day 7, 9 a.m, RH: 80.9%; **G3**:Day 7, 4 p.m, T: 26.1 °C; **G4**: Day 7, 4 p.m, RH: 75.6%; **H1**: Day 8, 9 a.m, T: 24.5 °C; **H2**: Day 8, 9 a.m, RH: 79.5%; **H3**:Day 7, 4 p.m, T: 24.5 °C; **H4**: Day 7, 4 p.m, RH: 79.3%;

Figure 21: Evolution of the maturation of the samples over the days

We notice that the tomato samples do not ripen at the same speed. Some took 6 days to reach red ripeness while others took 7 days and others 8 days. Still others will take even longer. After 4 days, some started to rot without having started to turn red. Others started to rot once they turned red. The voids that we observe in certain places on the images correspond to the void left by the completely degraded samples that we removed. After 6 days, 8 samples were completely rotten, so 27.5% of samples. After 7 days, two samples of the 29 were still green and in good condition. After 8 days, it was observed that 12 samples were ripe and in good condition, so 44.8%. The two samples which after 8 days are still green, reached red maturity at the end of the thirteenth day.

6 CONCLUSION

The study found that environmental conditions were not favorable for tomato fruits. It also revealed that a sample is made up of a cylindrical part and a conical part. The mean length of the tomato samples is 6.65 cm, the mean mass is 70.2 g, the mean volume is 60.2 cm^3 and the mean lateral surface area is 87 cm^2. The standard deviation of the mass assembly is 16.19 g and that of the volume assembly is 23.87 cm^3. Measuring water content showed that the water content of the sample at green maturity was lower than that at mid-ripe. The water content of the sample at mid-ripe was lower than that at ripe (red). The study of the evolution of the maturity of the samples collected at green maturity showed that the fruits did not ripen at the same speed. Some samples degraded at green maturity; others degraded once they reached red maturity. Just a few samples remained in good condition after reaching red maturity. This experience revealed that the equipment to be designed for the preservation of tomatoes must have a system for maintaining the temperature and relative humidity adequate for the preservation of tomatoes. This equipment must take into account the mean mass and mean volume of a tomato. Fruits intended for preservation must be of good quality and grown with natural fertilizers.

ACKNOWLEDGEMENT

This work was supported by the Institut de la Francophonie pour le Développement Durable (IFDD/Canada) /Projet de Déploiement des Technologies et Innovations Environnementales (PDTIE) funded by the Organisation Internationale de la Francophonie (OIF). The Organisation of African Caribbean and Pacific States and the European (EU) (FED/220421-370) through the project PEPITA-UN.

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