Oral Session | Postharvest/Food Technology and Process Engineering
[4-1015-A] Postharvest/Food Technology and Process Engineering (1)
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[4-1015-A-03] Effect of High Voltage Electric Field on the Shelf Life of Mini Tomato Fruits

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Keywords: High voltage electric field, climacteric fruits, respiration rate, Tomato

High voltage electric field (HVEF) which is a non thermal food preservation technique that processes food without leaving any chemical residues and radiation is one of the emerging and a new area of research in the field of food preservation. Recent research indicates the use of HVEF on agricultural commodities reduces respiration rates of climacteric fruits, inhibit enzymatic and microbial activity which leads to extending the shelf life of fruits and vegetables. A major advantage of using high voltage food preservation technique is that it consumes low energy and prohibits the use of any chemical preservatives. The main objective of this research is to investigate the effects of HVEF on the shelf extension of mini tomato fruits. Monitoring of physiological responses and quality evaluation were performed during the storage test period of 3 weeks. The mini tomato fruit samples were obtained from a local distributor in Kagoshima and the samples were carefully graded for optimum quality to be used in this experiment. The total duration of sample analysis was 3 weeks (21 days). In the first two weeks the samples were treated to continuous electric field treatment; this was the test to study continuous effect of electric field on sample quality. On the 3rd week; the electric field was shut off and samples were analyzed for further 1 week to test the shelf life storage stability of tomato fruits post EF treatment. For EF and control treatment the total frequency of monitoring or analysis was 7 times; which is a representation of different number of day intervals over the 2 weeks period. For shelf life storage testing period the samples were analyzed over a period of 1 week. Two distinctive type of EF setup was used to study the quality attributes and respiration rate respectively. For measurement of quality attributes, the samples were placed inside a large electric field incubator (High voltage 7kV A/C- power supply (N- TeFe II) at 60Hz) for EF treatment and for control experiment another similar type incubator was used but without EF treatment. The treatment temperature was 1^0C and relative humidity was approximately 95%. The quality attributes evaluated in this study were PLM (Physiological loss of mass), TSS (total soluble solid), Brix, hardness and color properties. For respiration rate measurement (CO_2) production, 2kV aluminum parallel plate configuration electric field setup was used. The HVEF system consisted of a power source with an output voltage of 2kV (NF Corporation Japan, Model: EC750SA) with A/C- power supply (sine waveform) at a frequency of 60Hz. The samples were placed into acrylic desiccator and sealed off with an air tight lid. One end of the desiccator was connected to the air pump via flexible tube while the other end was connected to much smaller desiccator that housed the CO_2 sensor. For control, similar setup was used but without EF plates in the desiccator. The entire system was setup inside the incubator with controlled temperature and RH. Four incubators with EF setup were used, each with a corresponding temperature of 0, 1, 3, 5^0C respectively. The CO_2 production of the fruits were assessed at 10 minute intervals for 2 hours. For post EF treatment analysis, the samples were transferred inside perforated bag with gas septum attached and the bags were sealed and further stored for 1 week to study shelf life stability. The gas concentration was analyzed using a gas chromatography machine. The experiments were performed in triplicates. Analysis of the PLM indicated that in the two weeks of continuous treatment, the electric field treated samples had suppressed weight loss on D1, D2 and D3 respectively, whereas for D7 and D10 samples; the control treatment showed more reduction in weight loss. During shelf life storage period, the PLM of EF samples was significantly lower than the control treatment. On day 7, maximum weight loss was seen, however the weight

loss of EF sample was still lower compared to control 0.60 and 0.87% respectively. The total soluble solid content of HVEF treated samples were higher in concentration compared to the control in the 2 weeks of continuous treatment. Post EF treatment, the EF samples still constituted to higher Brix content overall. On the day 7 of shelf life storage the average TSS content between EF and control sample were 7.06 and 6.52 Brix respectively. The fruit firmness during 2 weeks of continuous treatment indicated that on day 4 and 7, the EF samples were a lot slightly firmer with 0.84N and 0.83N difference between EF and control sample respectively. Post EF treatment, the EF treated sample were consistently firmer throughout the 1 week storage period with an average hardness of 6.7N for EF sample and 6.5N for control.

Effect of High Voltage Electric Field on the Shelf Life of Mini Tomato Fruits.

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ABSTRACT

In this experiment two distinct type of electric field setup was used to study quality attribute and respiration rate of tomato fruit (*Solanum lycopersicum*) during 2 weeks of continuous electric field treatment and 1 week of post electric field shelf life storage testing. The main focus of this experiment is to study the effects of electric field on the shelf life stability of tomato fruit. For studying quality attribute (PLM, Brix, color & hardness), a 7kV alternating current electric field setup was used. The results of samples treated with electric field had an overall suppressed weight loss, higher concentration of °Brix and firmer texture during 1 week of shelf life testing period compared to control. The Hunters color value showed no significant difference between electric field and control samples. For measurement of respiration rate (CO_2 yield), a 2kV aluminum parallel plate setup at four temperature levels of 0, 1, 3 & 5°C was used in this experiment. During 2 weeks of continuous electric field treatment samples exposed to 5°C had significantly lower $CO_{2\ yield}$ overall. For post electric field shelf life testing, samples stored under 3°C had least CO_2 production and comparatively electric field treated sample had suppressed CO_2 gas concentration than the control sample.

Keywords:
High voltage electric field
Mini tomato
Respiration rate
Shelf life
Post electric field
CO_2 yield

1. INTRODUCTION

Food preservation processes are important in extending the shelf life of foods. Fruits and vegetables due to their high metabolic activity and water content, tend to deteriorate in their quality rapidly once they are harvested. The reason as explained by (Tucker, 1993) is due to its metabolic activity that continues to occur even after harvest, thus making most fruits highly perishable commodities. This change is irreversible thus to maintain optimum quality and safety of the commodity effective preservation measures are paramount. Many factors are responsible in spoilage of agricultural commodities after harvest. The major factors that affect food spoilage include water activity, exposure to light and oxygen, pH, temperature, microbial and chemical factors such as enzymatic activities. As stated by (Anaparti, 2019) there are several factors that act together and their collective impact results in the complete decay of the food commodity. Therefore, the need for new post-harvest preservation technologies are very important for the extension of shelf life without significant loss in quality, freshness and consumer demands.

The existing post-harvest treatment facilities offers to be effective in fruit and vegetable preserving; however each kind of treatment facility has some limitations. Modified Atmospheric Packaging (MAP), for instance uses N_2/CO_2 stable gases and at low temperature environment for fruit and vegetable preservation storage but a study by (El-Kazzaz, M.K., Sommer, N.F. & Fortlage, R.J., 1983) reported that off-odors were produced when strawberries were kept under higher CO_2 atmosphere for more than 4 days as a result of anaerobic respiration. Elevated CO_2 (10% to 40%) was found to

degrade internal color and caused a decrease in anthocyanin content of the internal tissue of strawberry (Gil, 1997). Modified atmosphere packaging can help to extend the shelf-life of strawberries but the results can be variable (Shamaila, 1992). Another commonly used preservation technique is low temperature cold storage usually above 0ºC. The conventional cold storage temperature is 5^0C or below that; but its effects can be seen as chilling injury to fruits and vegetables. Chilling injury is simply damage to fruits and vegetables caused by temperature above the freezing point (0^0C) (Grant, 2019). At these temperature, the tissues weaken because they are not able to carry out normal metabolic process. Various physiological and biochemical alterations occur in the sensitive species in response to low temperature exposure. These alterations lead to the development of a variety of chilling injury symptoms, such as surface pitting, discoloration, internal breakdown, failure to ripen, growth inhibition, wilting, loss of flavor, and decay. Further research on new techniques and technologies on improved post-harvest preservation are therefore important.

High voltage electric field (HVEF) which is a non thermal food preservation technique that processes food without leaving any chemical residues and radiation is one of the emerging and a new area of research in the field of food preservation. Recent research indicates the use of HVEF on agricultural commodities reduces respiration rates of climacteric fruits, inhibit enzymatic and microbial activity which leads to extending the shelf life of fruits and vegetables. A major advantage of using high voltage food preservation technique is that it consumes low energy and prohibits the use of any chemical preservatives. Hence use of high voltage electric field (HVEF) is one the ways that tend retain quality and freshness of fruits and vegetables without any significant loss of quality attributes. As described by (Muthukumaran, 2009) in their paper that a major advantage of this technique is that it does not cause any significant change in food temperature during processing thus increasing this technology's capability to be applied to any temperature sensitive food matrix example fruits and vegetables

Previous researches carried out in this field suggest that the use of HVEF increases the shelf life of fruits and vegetables without undesirable heat, chemical and microbial effects. According to research by (Bajgai, et al., 2005) showed that upon treatment of Wase Satsuma mandarin fruits with alternating HVEF, the results showed that the fruits inhibited the degradation of the chlorophyll and flavonoids of the peels hence retaining color and flavor.

Furthermore, Emblic fruit (*Phyllanthus emblical L*) a fruit found in South Asia popular for its high vitamin C has also been studied under HVEF. According to the article, the fruits were treated by alternating current (AC) direct current (DC) with high voltage electric field of 430kV/m for 2 hours to study the physiological loss of mass (PLM). The parameters tested were rotting, color change and Vit. C content during storage at 4, 20 and 35 ^{0}C in open and closed polyethylene pouches respectively. Based on the findings of this experiment, the results showed that alternating current (HVEF) is found to have an extended shelf life of emblic fruit. The AC HVEF treated emblic fruits when tested for their hunter color values, rotting and Vit. C content showed that HVEF treated samples were much better in quality and freshness compared with the untreated samples (Bajgai, et al., 2005).

The main aim of this study is to evaluate the effects of high voltage electric field on the on the shelf extension of mini tomato fruits. Monitoring of physiological responses and quality evaluation were performed during storage test over a 3 week period.

2. MATERIALS AND METHODS

2.1 Sample preparation

Tomato fruit (*Solanum lycopersicum*) was procured form a local distributor in Kagoshima prefecture. The sample were carefully checked and graded for optimum quality, free of any visual defects like bruises and cuts. Samples which showed signs of molds were discarded.

2.1.1 AC- HVEF experimental set up & sample treatment plan

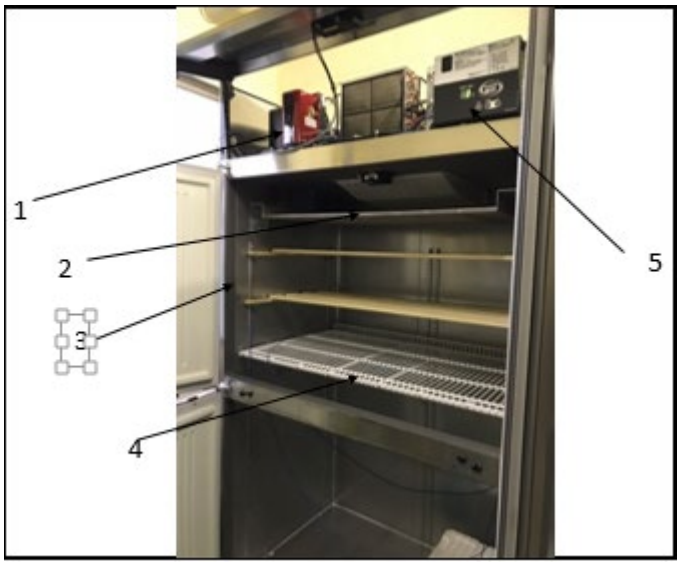

Fig. 1 HVEF setup used in measurement of quality attributes. 1; High voltage AC power supply, 2; conducting electrode, 3; incubator, 4; storage shelf, 5; temperature monitor

For measurement of quality attributes, the samples were placed inside a large electric field incubator (High voltage 7kV A/C- power supply (N- TeFe II) at 60Hz) (Figure 1) for EF treatment; and for control experiment another similar type incubator was used but without EF treatment. The treatment temperature was 1^0C and relative humidity was approximately 95%. The quality attributes evaluated in this study were PLM (Physiological loss of mass), TSS (total soluble solid), hardness and color properties. The total duration of sample analysis was 3 weeks (21 days). In the first two weeks the samples were treated to continuous electric field treatment; this was the test to study continuous effect of electric field on sample quality. On the 3rd week; the electric field was shut off and samples were analyzed for further 1 week to test the shelf life storage stability of tomato fruits post EF treatment. For EF and control treatment the total frequency of monitoring or analysis was 7 times; which is a representation of different number of day intervals (day 1,2,3,4,7,10 & 14) over the 2 weeks period. For shelf life storage testing period the samples were analyzed over a period of 1 week. The monitoring was 5 times (day 1,2,3,4 &7) in 1 week period.

2.1.2 Measurement of Physiological loss of mass (PLM)

In this experiment the cumulative loss of mass due to moisture loss of continuous electric field treated samples, post electric field shelf life test samples and control samples of tomato fruits were measured by weighing using a balance (Mettler Toledo PB3002-S, Switzerland ±0.01g). A total of 5 fruit samples were used for EF and control measurements respectively. The difference of weight for this five samples were then determined and their mean and standard deviation were calculated.

2.1.3 Measurement of Hunters Color value and total color difference

The Hunters color values units using the CIELAB ((Commission Internationale de l'Eclairage) color parameters expressed as *L* (lightness), *a* (green chromacity), and *b* (yellow chromacity) of continuous electric field treated samples, post electric field shelf life test samples and control samples of tomato fruits were measured on day 0 and on each designated day interval over 21 days of experiment period using a color meter (Minolta Chroma Meter Model CR-10 Plus (Minolta Tokyo, Japan)). For consistent reading, the fruit samples were marked at three place along the top portion of the fruit and the color reading were taken from middle part of the fruit which was just below the marked spots. Using equation 1 and CIELAB coordinate system of *L, a, b color* reading values were used to calculate the total color difference (▲*E*) (Chen, 2013). The Hunters color values reading of five samples were taken. The mean and SD of *L, a, b* values of fruit samples were determined.

$$\Delta E = \left[(L^* - L_0^*)^2 + (a^* - a_0^*)^2 + (b^* - b_0^*)^2 \right]^{1/2} \quad \text{(Eq 1)}$$

Where L_o, a_o, b_o are the initial values of fresh tomato samples on day 0 and *L, a, b* are final values

2.1.4 Measurement of Total Soluble Sugar Concentration or Brix

The total Brix content of the of continuous electric field treated samples, post electric field shelf life test samples and control samples of tomato fruits were determined by carefully slicing the fruit into

half. 1-3 drops of the tomato juice was squeezed onto the prism of the Brix meter and the readings were taken. Brix meter (Hybrid PAL-BXACID F5) model was used. The Brix readings of triplicate samples were taken. Mean and SD were then calculated.

2.1.5 Measurement of Fruit Firmness

For measurement of fruit hardness, a Rheoner II (Creep Meter PE2 330 SC) texture analyzer was used. A P79 (2mm) cylindrical needle probe was used to penetrate the fruit which was cut from the middle along the equatorial region and carefully the cut side was placed flat on base stage of the meter. The amount of force required to penetrate the fruit was recorded in Newton (N). The fruit hardness data of triplicate samples were taken and their mean and SD were calculated.

2.1.6 Measurement of Respiration rate (CO2 yield)

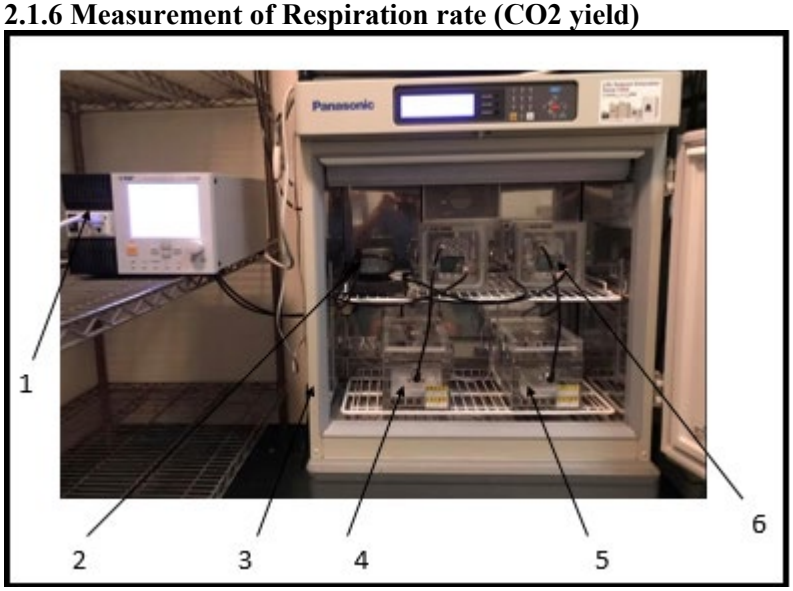

Fig. 2 HVEF setup used in measurement of respiration rate; 1; 2kV AC current power generator, 2; air pump, 3; Incubator, 4; acrylic desiccator for control treatment, 5; acrylic desiccator with parallel plate aluminum electrode, 6; smaller acrylic desiccator with CO_2 sensor.

For respiration rate measurement (CO_2) production, 2kV aluminum parallel plate configuration electric field setup was used. The HVEF system consisted of a power source with an output voltage of 2kV (NF Corporation Japan, Model: EC750SA) with A/C- power supply (sine wave) at a frequency of 60Hz. The samples were placed into acrylic desiccator and sealed off with an air tight lid. One end of the desiccator was connected to the air pump via flexible tube while the other end was connected to much smaller desiccator that housed the CO_2 sensor. For control, similar setup was used but without EF plates in the desiccator. The entire system was setup inside the incubator with controlled temperature and RH. Four incubators with EF setup were used, each with a corresponding temperature of 0, 1, 3, 5^0C respectively. The CO_2 production of the tomato fruits were measured as total gas accumulated on each day of analysis.

On day 14 the electric field was shut off. For post EF shelf life storage testing treatment, the samples were transferred inside perforated bag and the gas septum was attached on the upper side and the bags were sealed and further stored for 1 week at the same corresponding temperature of 0, 1, 3, 5^oC to study shelf life stability. The CO_2 gas production was analyzed using a gas chromatography machine (GC-4000 PLUS). The experiments were performed in triplicates. The mean and SD were calculated.

3. RESULTS AND DISCUSSION

3.1.1 Effect of HVEF on Physiological loss of mass of tomato fruit

Results of analysis of physiological loss of mass (PLM) of tomato fruits is shown in Table 1. The percent loss of mass as moisture loss was in a range of 0.21% to 2.12% for continuous electric filed treated sample of 2 weeks of treatment while for control treatment it was in the range of 0.31% to 2.08%. As shown by the Figure 3 the control sample had slightly higher weight loss on day 1 to day 3, however from day 4 onwards it was observed that the continuous electric field treated sample had a higher weight loss. For post electric field shelf life testing of 1 week, the results showed samples

which were treated with EF had an overall suppressed weight loss in range of 0.13- 0.60% after a week while the control samples were slightly higher in range of 0.20 – 0.80%. For both treatment types the weight loss was less than 1%. This findings suggest continuous electric treatment had a positive effect towards suppressing the weight loss of tomato fruit during shelf life test period.

Table1
Continuous effects of electric field treatment on Physiological loss of mass (of tomato fruits) treated for 2 weeks & Post EF shelf life storage test of 1 week at 1°C and 95% RH

Treatment Interval (days)	HVEF samples (%)	Control sample (%)	Treatment Interval (days)	HVEF samples (%)	Control sample (%)
	Continuous Electric Field treatment			Post EF shelf life Test	
1	0.21 ± 0.01	0.31 ± 0.10	1	0.13 ± 0.05	0.20 ± 0.04
2	0.32 ± 0.02	0.46 ± 0.10	2	0.25 ± 0.05	0.31 ± 0.04
3	0.45 ± 0.07	0.55 ± 0.09	3	0.36 ± 0.05	0.44 ± 0.03
4	0.67 ± 0.11	0.55 ± 0.09	4	0.49 ± 0.05	0.64 ± 0.04
7	1.08 ± 0.13	0.66 ± 0.26	7	0.60 ± 0.05	0.88 ± 0.09
10	1.51 ± 0.20	1.07 ± 0.03			
14	2.12 ± 0.34	2.08 ± 0.10			

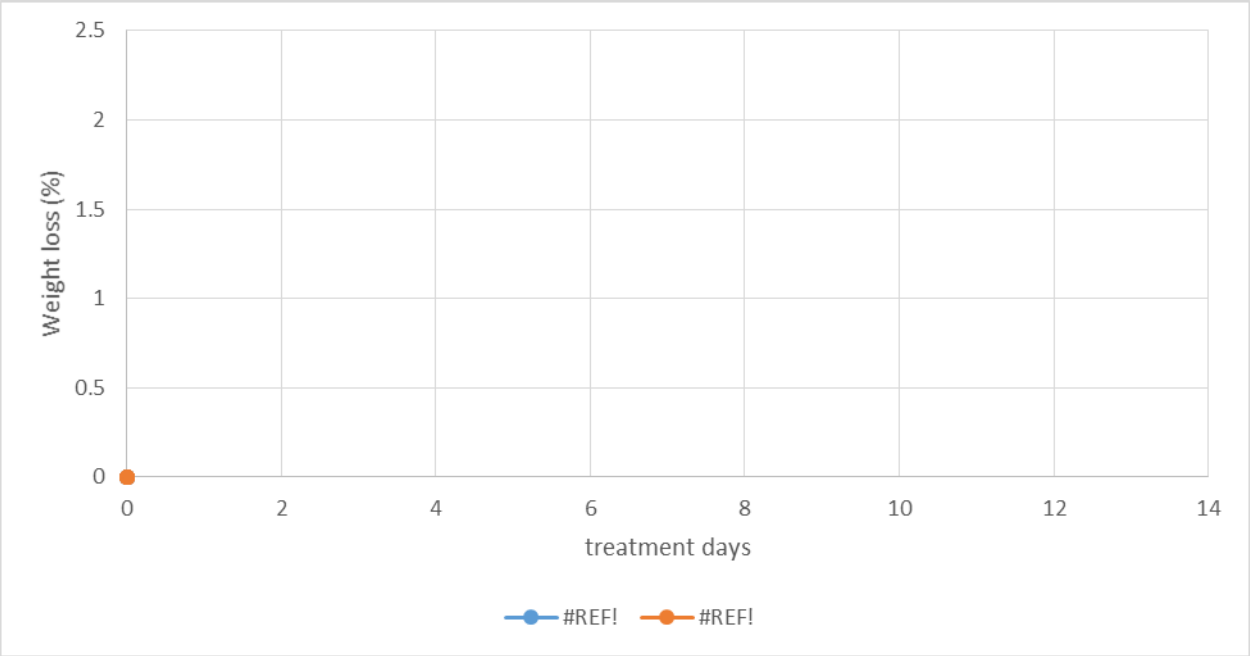

Fig 3. Physiological loss of mass of HVEF and Control samples after 14 days (1^0C; 95% RH)

3.1.2 Effect of HVEF on Hunters color value and total color change

The results from the Hunters color value of continuous electric filed treated samples and post electric field shelf life testing sample data are shown in the Table 2 & 3. For continuous EF treatment and control samples very little difference were evident between the initial and final color value (*L, a, b)* readings from day 0 to day 14. The results showed that difference between control sample and EF treated samples were very insignificant. The total color difference (▲*E*) was in range of 1.46 to 2.80 for EF samples and 0.74 to 2.97 for control samples. This value indicated fairly small difference. Except for day 10, where (▲*E*) value was maximum for both EF sample (5.72) and control (5.12) respectively. This increase in ▲*E* could have been result of some chemical or enzymatic activities that might have triggered. For post EF shelf life testing period, similar results were observed. There was very little difference between post EF treated samples and control samples except for day 7. On day 7 the total color difference was 4.61 for EF sample and 4.10 of control sample. Values in this range indicated perceptible difference between the color values.

Table2

Effects of HVEF on the Hunters color value of tomato fruit during 2 weeks continuous treatment

treatment interval	HVEF sample				Control sample			
(days)	*L*	a	b	▲*E*	*L*	a	b	▲*E*
0	-64.47 ± 2.75	11.17 ± 1.98	11.87 ± 1.81		-64.09 ± 1.86	10.92 ± 1.95	11.19 ± 1.56	
1	-61.62 ± 1.58	11.50 ± 2.13	11.96 ± 1.72	2.87	-61.22 ± 1.91	11.17 ± 2.22	10.49 ± 1.72	2.97
2	-62.75 ± 1.81	10.18 ± 2.03	11.03 ± 1.66	2.15	-62.58 ± 1.71	9.36 ± 1.84	9.33 ± 1.94	2.86
3	-62.92 ± 2.09	11.02 ± 2.53	11.76 ± 2.02	1.56	-63.95 ± 1.87	10.19 ± 1.74	10.74 ± 1.77	0.87
4	-62.44 ± 1.54	11.31 ± 2.30	11.90 ± 1.63	2.03	-62.90 ± 1.16	10.82 ± 1.87	10.86 ± 1.71	1.24
7	-63.16 ± 1.18	10.52 ± 2.15	11.78 ± 1.80	1.46	-63.66 ± 1.04	11.12 ± 1.92	11.76 ± 1.66	0.74
10	-60.17 ± 0.93	8.95 ± 1.74	8.82 ± 1.04	5.72	-60.34 ± 0.86	9.00 ± 1.53	8.06 ± 1.34	5.25
14	-62.88 ± 1.14	10.56 ± 1.81	12.01 ± 1.73	1.70	-62.94 ± 1.24	10.21 ± 1.65	11.35 ± 1.61	1.35

Table 3

Effects of HVEF on the Hunters color value of tomato fruit during 1 week post RF treatment shelf life test

treatment interval	HVEF sample				Control sample			
(days)	*L*	a	b	▲*E*	*L*	a	b	▲*E*
1	-62.12 ± 1.06	10.31 ± 1.64	10.68 ± 1.61	1.55	-63.03 ± 1.13	10.54 ± 1.68	11.29 ± 1.43	0.34
2	-62.53 ± 1.16	10.73 ± 2.00	12.20 ± 1.67	0.43	-62.22 ± 1.58	11.52 ± 1.81	12.65 ± 1.79	1.98
3	-61.82 ± 1.27	11.10 ± 1.93	12.63 ± 1.72	1.34	-62.28 ± 1.09	10.89 ± 1.69	11.72 ± 1.46	1.02
4	-60.06 ± 1.04	9.11 ± 1.74	10.03 ± 1.44	3.74	-59.68 ± 0.82	9.62 ± 1.77	9.85 ± 1.58	3.65
7	-59.21 ± 1.04	9.02 ± 1.54	9.68 ± 1.63	4.61	-59.42 ± 0.70	9.26 ± 1.29	9.48 ± 1.16	4.10

3.1.3 Effect of HVEF on Total Soluble Sugar, TSS (°Brix)

High °Brix concentration were observed for continuous electric field sample treatment for most days during the 2 weeks of treatment when compared with control (as shown in Figure 4). The TSS content of electric field samples were in range of 6.48 to 6.78 °Brix while control was in range of 6.41 to 6.87 °Brix. However on day 1 and 3 the control samples had slightly higher °Brix content of 6.79 and 6.87 °Brix. For post electric field shelf life testing period the electric field treated sample °Brix was overall higher with highest value recorded on day 7 of 7.06 compared to control. As shown in Figure 5 a continuous increase in °Brix content trend was seen with electric field sample whilst control sample °Brix showed a fluctuating trend.

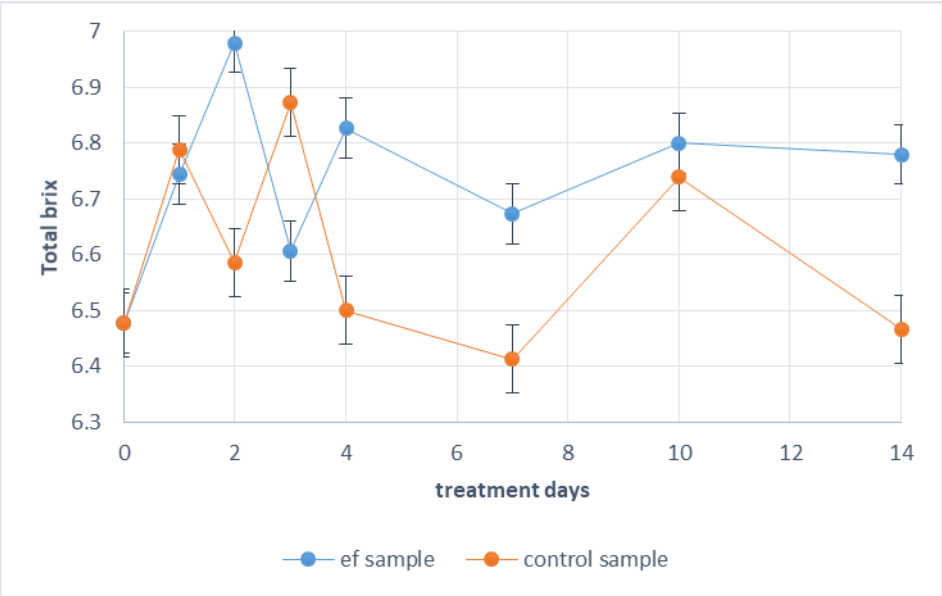

Fig. 4 Measured Brix values of continuous HVEF and control samples of 14 days of storage period (1^0C; 95% RH)

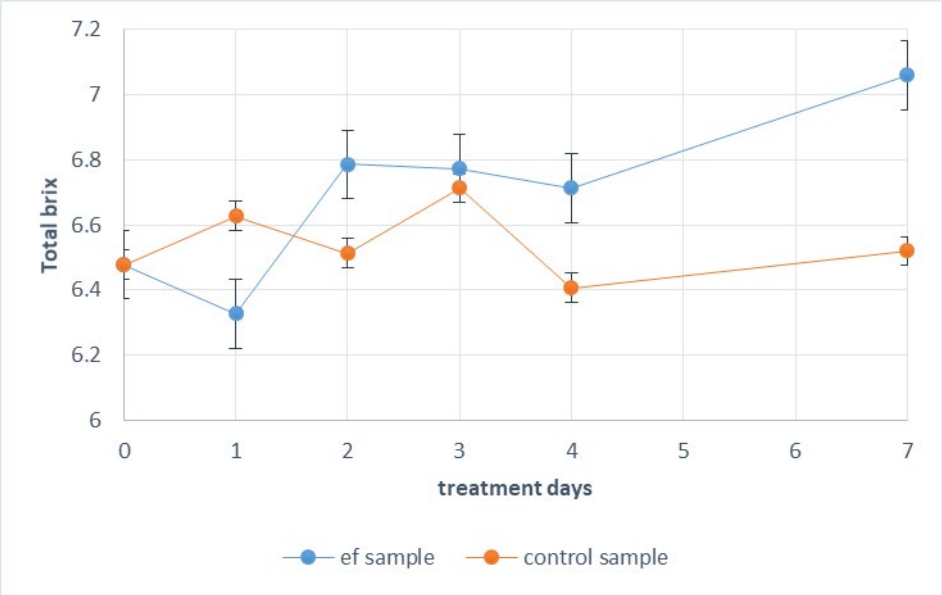

Fig. 5 Measured Brix values of post HVEF treatment and control samples of 7 days of shelf life storage testing period (1^0C; 95% RH)

3.1.4 Effect of HVEF on fruit firmness

Evaluating firmness is one of the important characteristic to determine the fruit texture and degree of ripeness or maturity of fruits and vegetables. Results from continuous electric field treatment as shown by Figure 6 indicated that electric field treatment did not have a significant effect on the fruit firmness. Overall the control sample tend to had more firm fruit texture except on day 4 and 7 where the EF treated samples were slightly firmer. The highest EF sample was 5.37N on day 4 while for control (5.87N) was the highest on day 2. For post electric field shelf life testing period the EF treated sample showed more firmness overall however the difference in firmness level was only slight compared to the control.

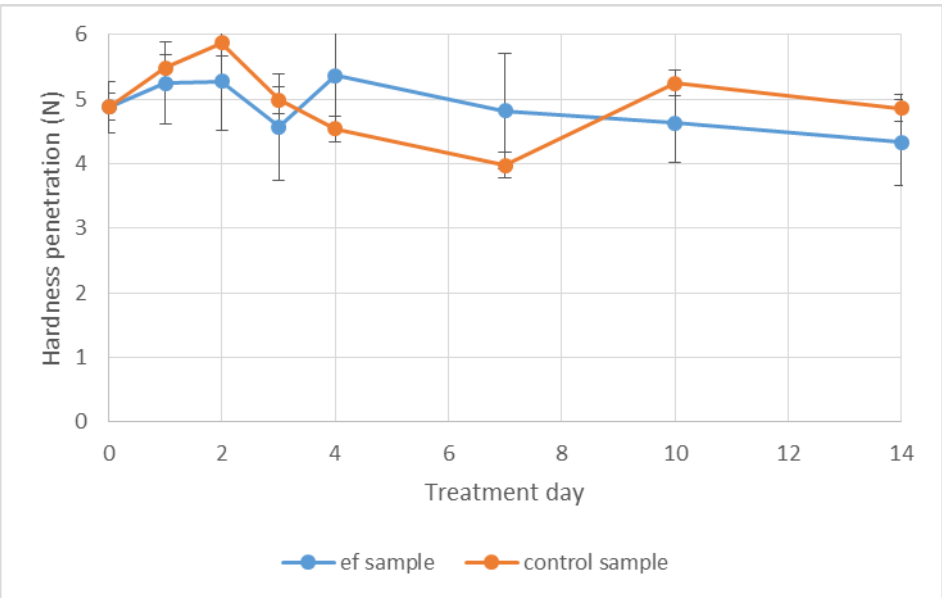

Fig.6 Fruit firmness level (N) of continuous HVEF and control samples of 14 days of storage.

3.1.5 Effect of HVEF on fruit respiration (CO_2 yield).

According to (Chi-En Liu., 2017) the rate at which the carbon dioxide gas is produced from the fruit can be used as an important physical parameter to determine the ripeness level of a fruit. In addition as described by (Bhande, 2008) that the rate at which the CO_2 gas produced has a direct impact on the life span of the fruit after harvesting. Its also described that CO_2 level is a good indicator of shelf life as the higher the rate of CO_2 production; the shorter is the shelf life. In this experiment the CO_2 production was measured by allowing CO_2 gas to accumulate inside the air tight dessicator. The CO_2 - level was measured every morning corresponding to the planned monitoring schedule during the 2 weeks of continuous treatment.

As shown by Figure 7, samples stored under 1°C had the highest production of CO_2 gas recorded followed by samples stored under 0°C for both the EF treated sample and the control. Samples that were stored under 3°C was found to be in medium range of CO_2 production. The least CO_2 yield was seen for sample stored under 5°C. The samples stored under 5°C had significantly lower CO_2 production overall. Observations under this treatment temperature, shows that samples treated to continuous electric field treatment had slightly high CO_2 production compared to control.

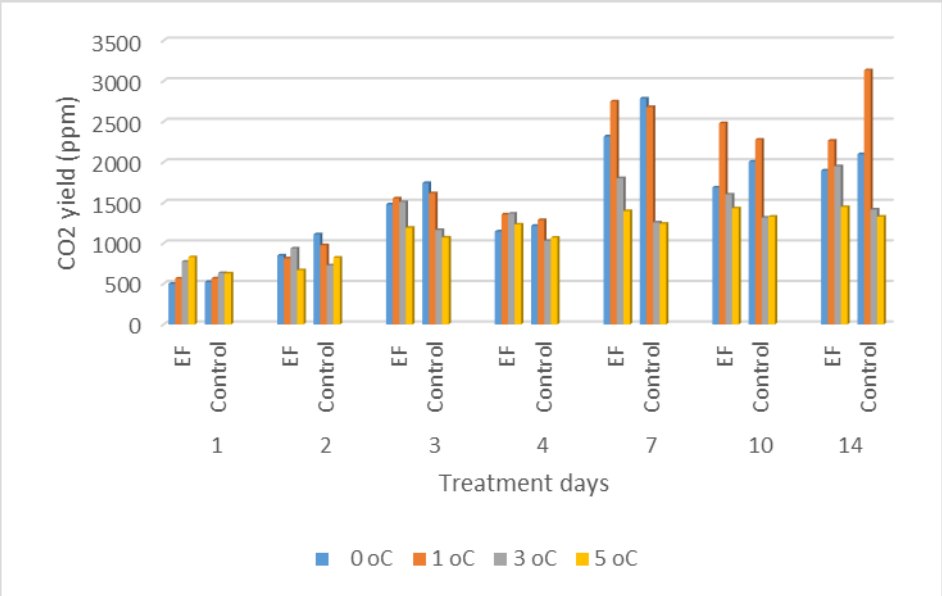

Fig 7 Carbon dioxide yield in ppm during 2 weeks of continuous electric field treatment

Post electric field treatment samples (Figure 8) that were stored under 3°C showed least percent of CO_2 production. It was also very clearly evident that samples exposed to continuous electric field treatment had suppressed CO_2 yield on all of the days. Similar trends were also observed with samples stored at 0°C and 1°C respectively.

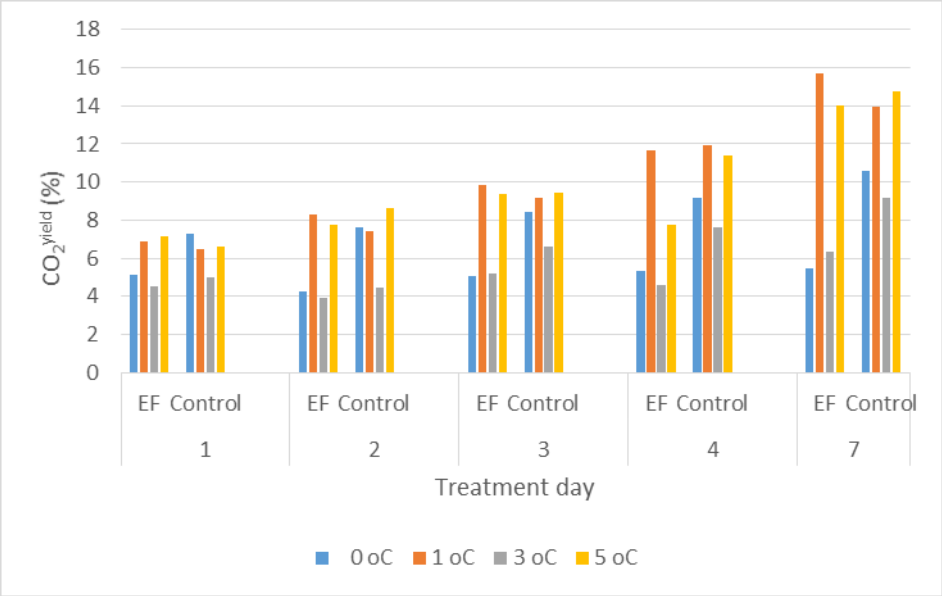

Fig 8 Carbon dioxide yield in % during 1 weeks of post electric field shelf life testing period

4. CONCLUSION

In conclusion 2 distinct type of electric field set up was used to study quality attributes and respiration rate on the shelf life extension of tomato fruits. The quality attributes were measured using a 7kV large incubator while the respiration was measured using 2kV aluminum parallel plate setup. The results showed that both type of electric field set up has a positive effect on extending the shelf life of tomato fruits. The 7kV electric field treated samples showed suppressed weight loss, firmer texture and higher Brix level during shelf life storage period. For Respiration results it was seen that at 3ºC the CO_2 was least during 1 week shelf life testing of electric field treated samples. It can be said that HVEF is effective in maintaining tomato fruits quality and freshness.

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