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Introducing pulsed electric field treatments for fruit juices industry in Egypt as an alternative of thermal pasteurization

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Abstract

The aim of this study was to investigate the efficiency test of a laboratory scale of pulsed electric field (PEF) device, on strawberry juices treated in a batch system. strength was (18.5 kV/cm for 500 µs at 100 Hz) for 60 sec. or 90 seconds as alternative physical and non-thermal method compared with those of thermal traditional method of pasteurization used Indirect heating by double jacket suit at (90^{o}C / 5 min) and unprocessed juice (Fresh juice) as a reference (Control) was studied in terms of effect of these treatments' physico-chemical characteristics, (TSS, pH, acidity and color), ascorbic acid, microbial stability and shelf life, of treated strawberry juices. After treatments and whether storage at room temperature at (22°C ±3) for 45 days or in refrigerator at (4°C ±1) for 105 days. Pulsed electric field device subject of study was effective as thermal pasteurization not only to achieve microbial stability juices, but also to obtain juices with a high content of vitamin C like fresh, perfectly.

Keywords: pulsed electric field device, thermal pasteurization, strawberry juices, microbial stability, shelf life.

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1. Introduction

The clinical incidence of drug-resistant microorganisms has increased dramatically today, influencing a growing need for new antimicrobial methods to be developed against major foodborne pathogens (McCrackin *et al*., 2016). Food-borne diseases affect more than 600 million people and cause 420,000 deaths annually, according to the World Health Organization (WHO) (Colavecchio *et al*., 2017; WHO, 2015). In addition, an increasing knowledge of diet and health problems has led customers to search for food items of superior nutritional and sensory quality, long-lasting shelf life which requires minimal processing (Walkling-Ribeiro *et al*., 2009). Many treatment approaches have been employed to resolve these issues, of which thermal pasteurization is commonly pronounced. Although thermal processing appears to have extended the shelf life of several juices, several studies have shown that there is a significant deterioration in sensory, nutritional and biochemical compounds that are highly heat sensitive (Sanchez-Vega *et al*., 2009). Scientists have come up with Pulsed Electric Field (PEF) as a non-thermal treatment process in response to this restriction, which has been shown to minimize microbes and spoilage enzymes to a degree comparable to that by thermal methods, without losing taste, color and bioactive compounds (Charles-Rodríguez *et al*., 2007). Pulsed Electric Fields (PEF) process involves applying a short burst of electric field to a sample placed between two electrodes that causes permeabilization-may be reversible or irreversible depending on the membrane-process parameters (Guo *et al*., 2014). Pulsed Electric Fields (PEF) apply intense, high voltage electrical field pulses to biological materials and induce breakdown of cell membranes, mainly lipid bi-layers. PEF can be used to pasteurize foods which are fluid and pumpable. The benefit of PEF is the retention of product quality and freshness (Ramaswamy *et al*., 2005). The most widely accepted theory behind cell permeabilization is that free charges accumulate on both sides of the membrane under external electrical field exposure resulting in transmembrane potential and when the induced membrane potential reaches critical field power, membrane disruption or destruction (Aronsson *et al*., 2005). Strawberry and its derivatives are of great interest, as they are high in vitamin C and a good source of phenolic compounds like flavonoids and phenolic acids (Olsson *et al*., 2004). In this context, non-thermal technologies such as high-intensity pulsed electric welds (HIPEF) have gained increased attention due to their ability to retain juices while preventing the harmful effects of heat pasteurization (Deliza *et al*., 2005). The experiment was conducted during February 2018 at the Food Science and Technology Laboratory, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. The objective of the present work was therefore to assess and compare the effects of PEF and thermal pasteurization on analytical characteristics, microbial stability, shelf life, ascorbic acid and sensory quality properties evaluation of treated strawberry juice. In the present study, strawberry juices wear treated with

pulsed electric field technology as an alternative method of juice preservation. juices were treated with two levels of pulsed electric field at room temperature firstly: PEF1 treatment carried out by using 18.5 kv for 60 s and secondly: PEF2 treatment by using 18.5 kv for 90 s) and compare it with traditional thermal pasteurization at (90 ^{o}C / 5 min) and unpasteurized juice (fresh) as control samples.

2. Materials and methods

2.1 Material

Strawberry fruits (*Fragaria ananassa* Duch, cultivar Baladi) used in this investigation was purchased from local market (Tawfikea market Cairo, Egypt). All chemical obtained from Sigma Chemical Company (Germany) and purchased from El-Gamhouria Trading Chemicals and Drugs Co., Egypt.

2.2 Methods

2.2.1 Technological methods

2.2.1.1 Preparation of strawberry juice

The fruit was washed followed by sorting, Remove the green parts, drained and chopped then; Strawberry juice was extracted using juice extracting machine Kumtel (KM95FP2 1.750-liter blender chopper safety switch 750-Watt voltage: 240 - 220 50 Hertz Multiple speeds Turkey). To make a clear juice filtered through a stainless-steel filter then, a muslin cloth finally, the sugar was added by 5% according to the (ES: 1579-1/2005).

2.2.1.2 Design and preparing of pulsed electric field unit (apparatus)

Pulsed electric field (PEF) unit was used in this study depicted in Figure (1) and which is designed and prepared at the Agricultural Products Process Engineering Department, Faculty of Agricultural Engineering, Al-Azhar University, Nasr City Cairo, Egypt. PEF treatment of food offers the ability to inactivate microorganisms and enzymes with minimal effects on the nutritional, sensory and functional characteristics of food products due to the absence of heat (Table 1). Using of used PEF technology is based on the application of pulses with high voltage typically 18.5 KV/cm, derived to the product placed between two stainless steel electrodes in a static treatment chamber and the gap between two electrodes was 3.5 cm. The large electric intensities are achieved through storing large amount of energy in a capacitor bank (A series capacitors) from a direct current power supply, which is then discharged in the form of high voltages pulses. The pulse caused by the discharge of electrical energy from the capacitors is allowed to pass through the food materials for extremely short period of time (4μs) and can be conducted at moderate temperatures. The treatment time was (500 μs) and pulse frequency was (100 Hz). Oscilloscope used for

measuring pulse volt, frequency, pulse width and then, total treatment time was evaluated. The PEF unit was consisted of the following main components presented in Figure (1):

1. Power source: the power source was from the alternating current (AC) that transformed to direct current (DC) used to charge three capacitors in series, which then charged in the form of high voltage pulses.

2. High volt: cables for transferring pulses to the static treatment chamber.

3. Treatment chamber: Treatment chamber was made of Teflon as (food grade) in cylindrical can chap with a disc cover. Two electrodes of stainless steel (3mm) Thickness, first electrode used to conduct high volt pulses to juice, and then transferred to the ground through the other on.

2.2.1.3 Traditional thermal pasteurize-ation of strawberry juices

The traditional method of pasteurization was applied by using indirect heating of the juice in double jacket suit at (90 ^{o} C / 5 min), Then the pasteurized juices were packed in clean bottles and cooled to room temperature according to (Sorrivas *et al*., 2006).

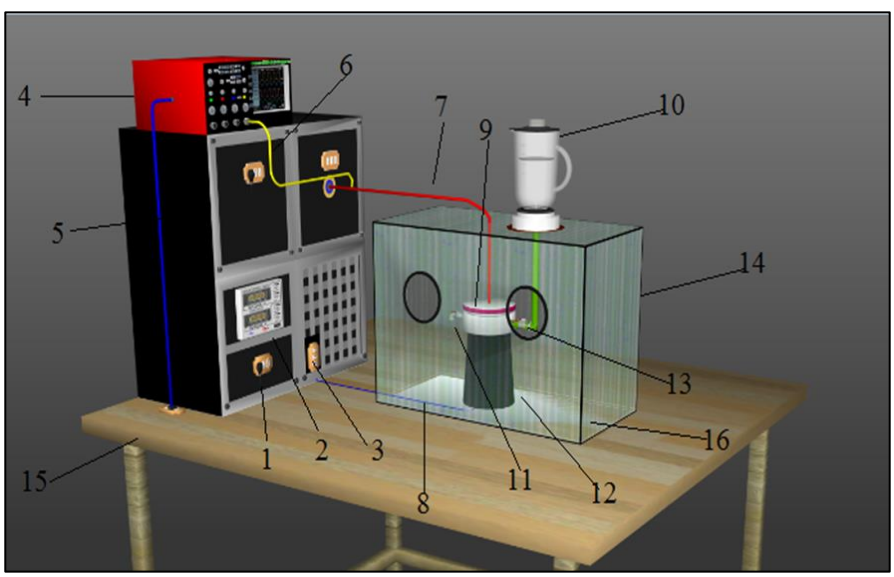

Figure (1): The pulsed electric field unit. 1= Source of electricity, 2 = DC Volt generator, 3 = Power switch, 4 = Oscilloscope, 5 = Pulse generating unit, 6 = Oscilloscope cable (+), 7 = High volt cable (+), 8 = Ground cable (-), 9 = Treatment chamber (Teflon), 10 = Inlet fresh juice, 11 = Outlet treated juice, 12 = Polyvinyl chloride stand, 13 = Control valve, 14 = Clear glass cover, 15 = Supporting wood frame, 16 = Marble.

2.2.1.4 Packaging and storage of treated strawberry juices

PEF and TP fluid systems were disinfected firstly with 4% of NaOH and then with 10% chlorine and 20% ethanol solutions prior to processing. The glass bottles were carefully washed and then sterilized by an electric oven (180°C /120 min). and the used capsules sterilized (wet sterilization) in boiled water (100 °C / 45 min). These glass sterile bottles of 250 mL were used to store the strawberry juices. Once filled, the receptacle was tightly closed and stored in the absence of light and with minimal headspace volume according to Salvia-Trujillo *et al*. (2011). Also, four treatments of bottled juices were prepared as follow: First treatment: Unpasteurized strawberry juice control (C). Second treatment: pasteurized strawberry juice by traditional thermal pasteurization at (90 ^{o}C / 5 min) (TP). Third treatment: juice treated by Pulsed electric field at (18.5 kv /60 s) (PEF1). Fourth treatment: juice treated by Pulsed electric field at (18.5 kv /90 s) (PEF2). Strawberry juices were divided into two parts, first part stored at room temperature (22°C ±3) for 45 days. And the second part was kept at refrigerator at (4 °C ±1) for 105 days Three bottles of juice samples from each treatment were randomly taken for microbial analysis, and another three bottles were used for phesico-chemical and sensory analysis periodically according to Guo *et al*. (2014).

2.2.2 Analysis methods

2.2.2.1 Physico-chemical characteristics

2.2.2.1.1 Total soluble solids, pH value and total titratable acidity

Total soluble solids (T.S.S), pH value and total titratable acidity (TA) were determined according to the methods described by AOAC (2005).

2.2.2.1.2 Color determination of juices

Untreated samples (fresh), treated samples by using (TP) and treated samples by using PEF1 or PEF2 were evaluated by measurement of transmittance at 510 nm for strawberry juices according to Bakker *et al*. (1992) using a spectrophotometer (6505 UV/Vis, Jenway LTD., Felsted, Dunmow, UK). All juices were centrifuged 10 min at 3000 rpm before the measurement.

2.2.2.1.3 Determination of ascorbic acid

Ascorbic acid content was estimated according to AOAC (2005) using 2.6 dichlorophenol-indophenols by titration method. Data was expressed as mg ascorbic acid per 100 ml samples.

2.2.2.2 Microbiological analysis

2.2.2.2.1 Total plate counts

Total colony count of bacteria was estimated using plate count agar medium according to the procedures as described by FAO/WHO (1995). The plates were incubated at 37°C for 48 h.

2.2.2.2.2 Molds and yeasts count

The mold and yeast were determined using the Potato dextrose agar medium (PDA) according to Difco Manual (1998) .The plates were incubated at 25°C for 5 days.

2.2.2.2.3 Psychrophilic bacterial counts

Psychrophilic bacterial count was estimated as described in typical procedure of the total bacterial count method, except incubation was carried out at 7ºC for 5 days in refrigerator according to American Public Health Association (FAO, 1992). In all microbiological analysis after incubation, colony forming units (CFU) were counted using a digital colony counter. Data was expressed as (log CFU) per milliliter of juice.

2.2.2.3 Shelf life of pasteurized juices

Determination of the shelf life for treated samples of strawberry juices were carried out according to the method of Vegara *et al*. (2013). Samples were stored at room temperature (22°C ±3) for 45 days or at refrigerator at (4 °C ±1) for 105 days. The microbiological, sensorial and physiochemical properties were conducted periodically during (storage period). The sample is expired when the sample deviates from the microbial and chemical boundaries and the attendant changes in quality according to the Egyptian standards.

2.2.2.4 Statistical analysis

All results obtained of different tested strawberry fruit juices were analyzed using comparison of means using Fisher's protected least significant difference (LSD) at $p \leq 0.05$ (Gomez and Gomez, 1984; Steel and Torrie, 1980) and the standard error was calculated using the statistical analysis software "CoStat 6.4" (CoStat, 2005).

3. Results and Discussion

3.1 Characterization, parameters and temperatures of pulsed electric field processing of juices as compared to the traditional thermal pasteurization

The characterization and parameters of pulsed electric field device were strength 18.5 kV/cm, pulsed frequency 100 Hz, pulse width 4 μs, treatment time 500 μs these measurements were obtained by using oscilloscope unit according to Gad and Jayaram (2011) (Table 1).

3.2 Physicochemical characteristics of treated and non-treated strawberry juices by thermal pasteurization and pulsed electric field

The TSS of treated strawberry juices as shown in Table (2) were 10.45, 10.62, 10.45, 10,47 Brix for control sample and samples treated with conventional thermal pasteurization and samples treated with electric pulse for 60 s and for 90 s, respectively. Besides, it was observed little increase ($P \geq 0.05$) in TSS of thermal processed sample as compared

with PEF treated sample which was at the level of control.

Table (1): Characterization, parameters and temperatures of pulsed electric field processing of juices as compared to the traditional thermal pasteurization.

Processing Parameters	TP	PEF_1	PEF_2
Electric filed strength (kV/cm)	-	18.5	18.5
Pulsed frequency (Hz)	-	100	100
Pulse width (µs)	-	4	4
Treatment time (µs)	-	500	500
Total treatment time (min)	5	1	1.5
Temperature of juices before Processing (^{o}c)	21	21	21
Temperature of juices after Processing (^{o}c)	90	21.3	22.5

TP =Thermal pasteurization at 90 ^{o}C / 5 min. $PEF_{1=}$ Pulsed electric field using 18.5 kv for 60 s. PEF_2 = Pulsed electric field using 18.5 kv for 90 s.

Table (2): Physicochemical characteristics of treated and non-treated strawberry juices by thermal pasteurization and pulsed electric field.

Parameters	Strawberry juice			
	Before treatment (C)	After treatments		
		TP	PEF1	PEF2
T. S. S (Brix)	10.45^b	10.62^a	10.45^b	10.47^b
pH value	3.64^a	3.49^b	3.64^a	3.63^a
T. A.% (as citric acid)	0.77^a	0.80^a	0.77^a	0.78^a
Color (O.D) nm	12.88^a	5.99^d	12.79^b	12.73^c

Values in the row followed by the same letter within a row are not significantly different as determined by the LSD test (P= 0:05). C = Control, TP = Thermal pasteurization, PEF1 = Pulsed electric field using 18.5 kv for 60 s, PEF2= Pulsed electric field using 18.5 kv for 90 s.

Also, from Table (2) it is clear that, the control sample of strawberry juices recoded pH (3.64). While, it was recorded the pH values after TP, PEF1 and PEF2 (3.49, 3.64 and 3.63, respectively). As for total acidity estimated as citric acid before and after treatments of samples recorded 0.77, 0.80, 0.77 and 0.78 for control sample and those treated with TP, with PEF 18.5 kv for 60 s and samples treated with PEF 18.5 kv for 90 s, respectively. Color is the most important quality factor of fruit juice for the consumer, and the best color for strawberry juice was to samples treated with pulsed electric field as compared with the control sample since the transmittance (T) recorded were (12.88- 5.99 - 12.79 and 12.73) for control, the samples treated by TP, PEF for 60 s and for 90 s respectively. In addition, the thermal processing of strawberry juice negatively affected on the natural color of the juice (50% reduction) as compared with the color of PEF treated strawberry juice (López *et al*., 2008). As for, the effect of thermal and PEF processing on sugar content of strawberry juice, it was noticed clear loss in reducing and non-reducing sugars in samples treated with thermal processing as compared with samples treated with

PEF for 60 s or for 90 s. These results are in agreement with the results obtained by Schilling *et al*. (2007) who reported that PEF treatments of fruit juices did not affect the physicochemical properties (such as pH, acidity, soluble solids, and color) of fruit juices. Finally, from the obtained data in Table (2), it could be concluded that the physicochemical and quality properties of PEF treated strawberry juices were near to that of the control samples and superior the quality of thermal pasteurized juices. Also, it can be said that processing of examined fruit juices by PEF technique significantly ($p \geq 0.05$) improved their quality characteristics, Thus, PEF technology is able to preserve fruit juices and maintaining their fresh-like characteristics. These results are in agreement with (Charles-Rodriguez *et al*., 2007; Noci *et al*., 2008).

3.3 Ascorbic acid content

The changes in ascorbic acid of strawberry juices were determined during storage period at room or cooling temperatures. The obtained results were recorded in Figures (2) and (3), The results indicated that the ascorbic acid for strawberry juices decreased with increasing of storage period at both room and cold temperature. The decrease in vitamin C content of the juice was more reasonable in samples preserved by TP as compared with samples preserved by PEF method. Also, retain in vitamin C content of strawberry juice was gradually decreased by increasing the storage period. The level of vitamin C decrement at room or cooling temperature. The amount of decreasing ranged from 15 to 40 % depending on the preservation method used and the storage conditions of the juices different studies have proved the effectiveness of PEF in achieving higher vitamin C retention in comparison to heat treatments. These findings are in agreement with Odriozola-Serrano *et al*. (2008) and Klopotek *et al*. (2005). Treated strawberry juice samples by PEF1 and PEF2 and best returned vitamin C content during storage period at room temperature compared with TP samples. Lower processing-temperatures reached through PEF processing ($T < 25$ °C) would explain the higher retention of vitamin C in PEF-treated strawberry juice compared to the thermally-processed samples. Also, a period of cold storage (75 day) the ascorbic acid content in samples reached to (36.75, 71.15 and 71.80 mg /100 ml) for the samples treated by TP, PEF1 and PEF2 respectively. Finally, it could be concluded that the strawberry juice samples treated by PEF1 and PEF2 and stored at refrigerator temperature was the best for prolongating the keeping quality and vitamin C content of the juice as compared with TP. Our results are consistent with those published by Alighourchi *et al*. (2008) and Yildiz *et al*. (2019).

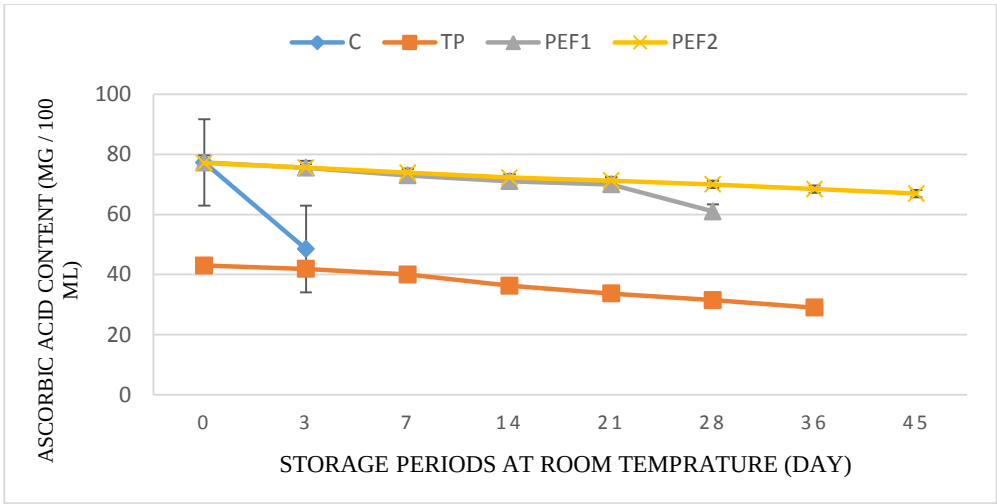

Figure (2): Effect of storage periods at room temperature on ascorbic acid content of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

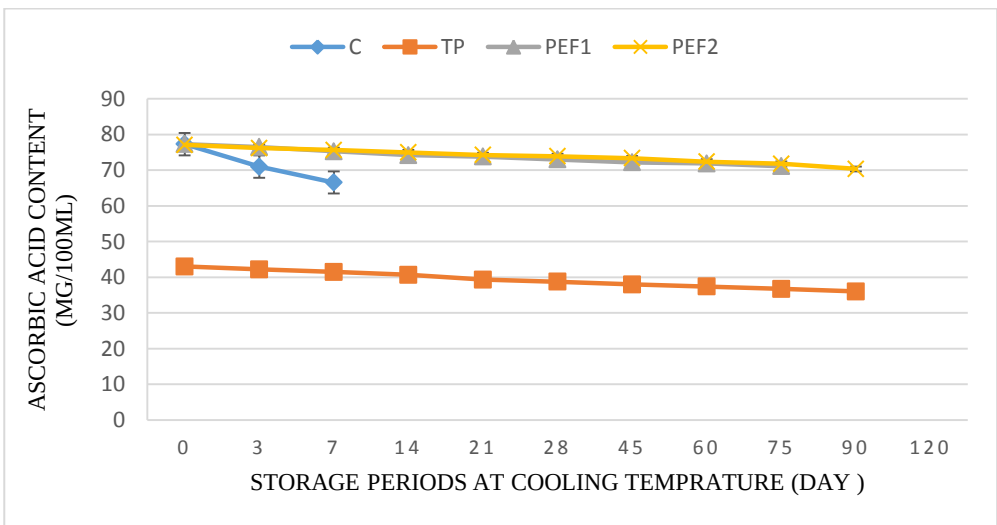

Figure (3): Effect of storage periods at cooling temperature on ascorbic acid content of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

3.4 Effect of storage periods at room and cooling temperature on total microbial count of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization

3.4.1 Total bacterial count

From the obtained results in Figures (4) and (5), it could be notes that the control samples unpasteurized of strawberry

juice had the higher total bacterial count than that of other pasteurized ones. Since, the treated samples with TP, PEF1and PEF2 and stored at room temperature had lower total bacterial counts than control. Furthermore, the total bacterial counts are gradually ($p \geq 0.05$) increased with increasing storage periods for all pasteurized strawberry juice samples. The more effective treatment was PEF2 which gave low TPC load 4 after 45 day of storage at room temperature. On the other hand, all strawberry juices were treated by TP, PEF1 and PEF2 stored at refrigerator had lower total bacterial counts than the same treatments stored at room temperature. Besides, the storage time with acceptable acidity was prolonged to 75-90 day at cold storage instead of 36-45 day at room temperature (Vegara *et al*., 2013). Finally, it could be concluded that the strawberry juice samples treated by electrical pulse (PEF2) and stored at refrigerator temperature was the best treatments. From the point of microbial load and quality of the juice, it could be proposed that the TP, PEF1 and PEF2 treatments of strawberry juice inactivate the microbial load by about 50- 60 % but the microbial cells began to activate during storage at room or cold temperature the increase in microbial growth was more intensive at room temperature than at cold one. The aforementioned results are in agreement with the results of Huang and Wang (2009) and Toepfl e*t al*. (2007) who reported that, there is significant relations between electric field strength as well as treatment time and microbial inactivation efficiency (Ghanshyam *et al*., 2011).

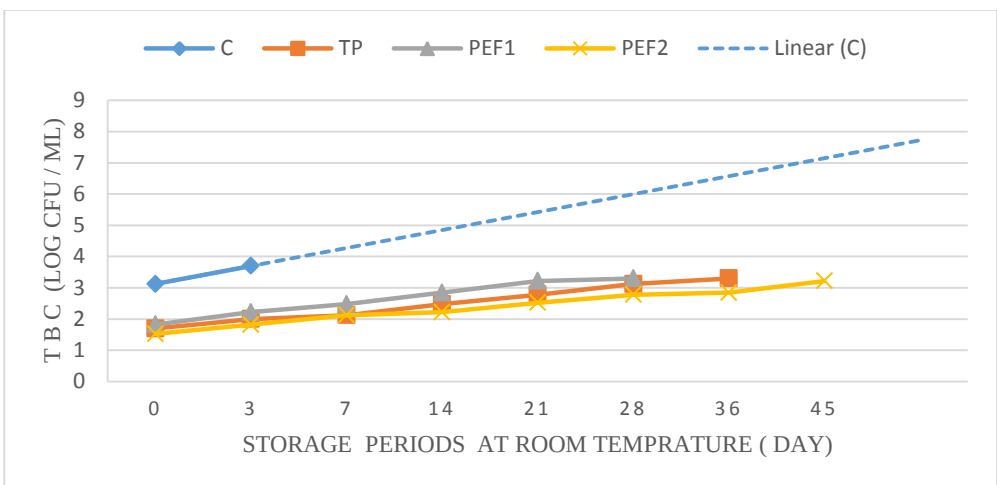

Figure (4): Effect of storage periods at room temperature on total bacterial count (TBC) log cfu /ml of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

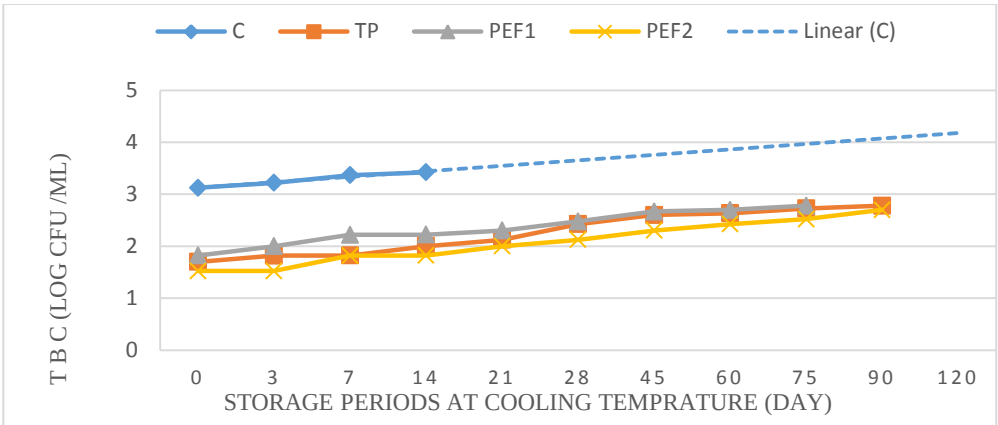

Figure (5): Effect of storage periods at cooling temperature on total bacterial count (TBC) log cfu /ml of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

3.4.2 Psychrophilic bacteria

The changes in the psychrophilic bacteria counts (PbC) of strawberry juice samples were determined during storage period at cooled temperature. The obtained results are shown in Figure (6), and indicated that the psychrophilic bacteria count gradually increased with increasing storage period at cooled temperature the growth of PbC appeared in pasteurized samples after induction period of 37 day from the beginning of storage time. For example, in control samples of strawberry juice samples stored under cooling temperature the psychrophilic bacteria counts increased from 2.123 log cfu /ml at initial storage at cool temperature to 2.522 log cfu /ml after 7 days of storage. At the same time psychrophilic bacteria counts for strawberry juice samples treated by TP, PEF1 and PEF2 reached to1.8, 2.0 and Nil after 7 day of storage and 2.123, 2.220 and 1.819 log cfu/ml respectively after 14 days of storage. While, at the end of storage after 75 days the (pbc) reached to (2.636, 2.698 and 2.563 log cfu/ml) for TP, PEF1 and PEF2 respectively. Similar results were concurrent with that found by Morales-de la Peña *et al*., (2019) and Wibowo *et al*. (2019). Finally, it could be concluded that the orange and strawberry juice samples treated by PEF2 and stored at refrigerator were the best treatments concerning the microbial count and keeping quality of the juices.

3.4.3 Molds and yeasts count

From the obtained results in Figures (7) and (8), it could be noticed that the control of strawberry juices had higher molds and yeasts count than that of pasteurized other treatments by TP, PEF1 and PEF2.

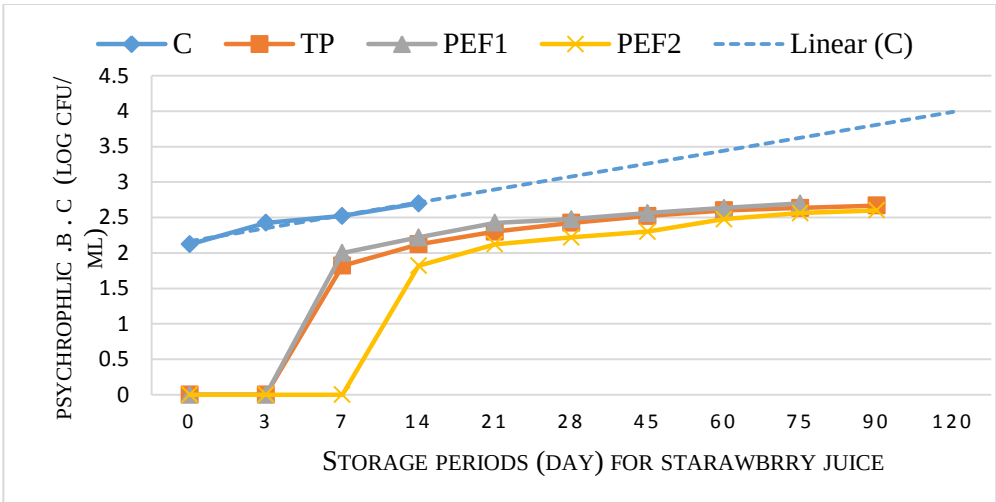

Figure (6): Effect of storage periods at cooling temperature on psychrophilic bacteria log cfu /ml of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

Also, the mold and yeast growth was absent in samples treated with TP and PEF methods for 3 and 14 day of storage at room and cold temperature respectively after the storage period the growth began to appeared in the juice except that samples treated by PEF2 while have long induction period 28 day at cold temperature. Also, the mold and yeast growth gradually increased by increasing the storage time. The in cerement of mold and yeast count was lower at cold storage as compared with its count at room temperature. For example, in control samples of strawberry juice stored at room temperature the molds and yeasts count increased from 1.98 log cfu/ml at initial storage at room temperature to 2.477 log cfu/ml after 3 days of storage. At the same time molds and yeasts count for strawberry juice samples treated by TP, PEF1 and PEF2 reached to (2.52, 2.70 and 2.37 log cfu /ml) respectively after 28 day of storage with accepted quality. On other side, the strawberry juice samples stored under cooling temperature were characterized with lower molds and yeasts count increased to reach (2.37, 2.49 and 2.00 log cfu/ml) respectively. for TP, PEF1 and PEF2 after 45 day of cooling storage and at the end of cold storage after 75 day the mold and yeast count reached to (2.56, 2.67 and 2.37 log cfu /ml) for TP, PEF1 and PEF2 respectively. finally, could be concluded that retained its microbial and keeping quality for 75-day strawberry juice treated by (PEF2) and stored at cooling temperature .These results are in

agreement with those obtained by Heinz *et al*. (2002), Chen *et al*. (2013) and Barba *et al*. (2020) who stated that the PEF treatment of fruit juice microbial caused inactivation and prolonged the keeping quality of the juice.

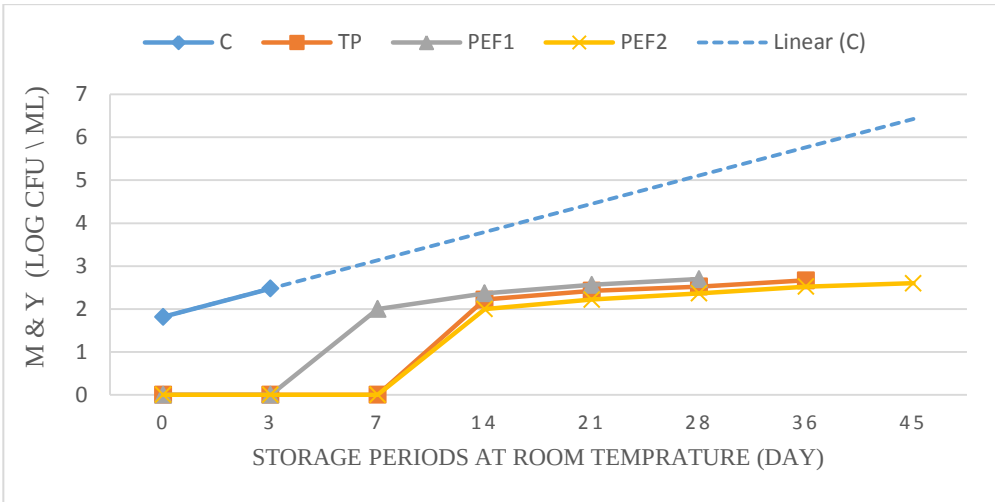

Figure (7): Effect of storage periods at room temperature on molds and yeasts count log cfu /ml of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

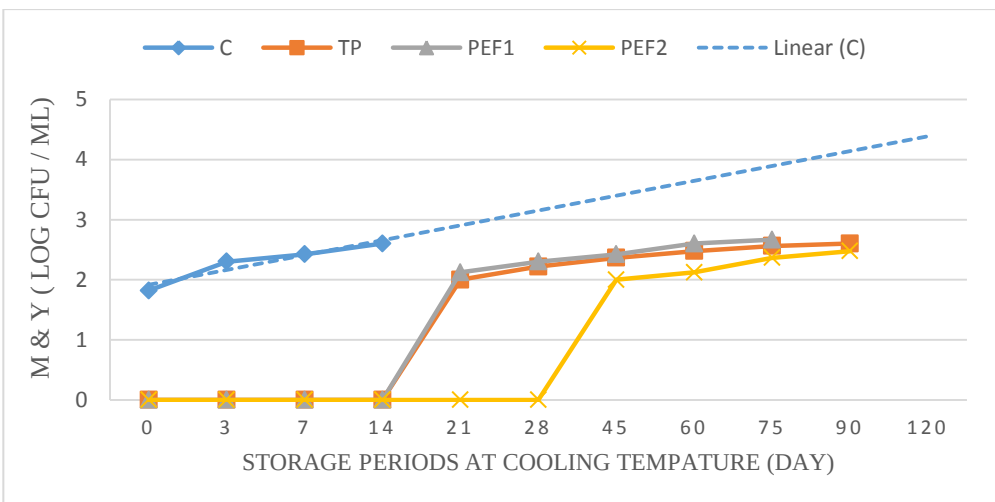

Figure (8): Effect of storage periods at cooling temperature on molds and yeasts count log cfu /ml of strawberry juices treated by pulsed electric field as compared to the conventional thermal pasteurization.

3.5 Effects of pulsed electric field treatment as compared to the conventional thermal pasteurization on shelf life by day of strawberry juice

Pulsed electric field (PEF) technique is effective at inactivating spoilage microorganisms in liquid foods such as juices thereby extending shelf life and often improving quality (Min *et al*., 2007). The obtained data of the shelf life by day of orange and strawberry juice samples treated with PEF and thermal processing are recorded in Table (3) and Figure (9).

Table (3): Effects of pulsed electric field treatments as compared to the conventional thermal pasteurization on shelf life by day of strawberry juices.

Methods of storage	Treatments			
	C	TP	PEF_1	PEF_2
Room temperature at 22 ±3 ^{o} C	1	36	28	45
Refrigerated storage at 4 ±1 ^{o} C	7	90	75	90

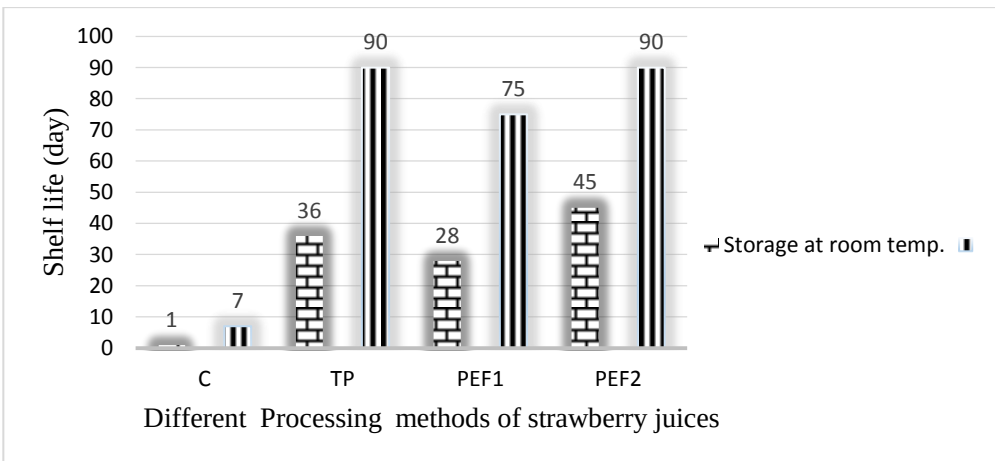

Figure (9): Effects of pulsed electric field treatment as compared to the conventional thermal pasteurization on shelf life of strawberry juices by day.

3.6 Effects of pulsed electric field treatments as compared to the conventional thermal pasteurization on shelf life by day of strawberry juices

Samples treated with PEF and thermal pasteurization were stored at both room and cooling temperature. The samples were subjected to physiochemical and microbial analyzes and sensory evaluation throughout storage periods to determine their shelf life. The results obtained showed shelf life for orange juice stored at room temperature (1, 45,

28 and 45 days) for control, TP, PEF1 and PEF2 treated samples respectively. As for orange juice samples stored on refrigeration, it was recorded shelf life (7, 90, 90 and 105 days) for both control samples and samples treated with conventional thermal pasteurization and samples processed with pulsed electric field treatment for 60 s and for 90 s, respectively. On the other hand, strawberry juice stored at room temperature was recorded shelf life (1, 36, 28 and 45 days) while, treated and untreated strawberry juice samples stored on refrigeration still accepted for 7, 90, 75 and 90 days for both control samples and samples treated with conventional thermal pasteurization and pulsed electric field treatment for 60 s and for 90 s, respectively. In addition, PEF-treated orange juices and strawberry juices exhibited cloud stability during storage comparable to thermally pasteurized juices the obtained results are in agreement with the results reported by Min *et al*. (2003), and Buckow and Toepfl (2013).

4. Conclusion

This study showed that PEF-processed strawberry juice had a microbiological shelf-life comparable to thermally processed juices mean while having similar quality and nutritional values as the unpasteurized juices. And preserving juice content from vitamin C, without deterioration of appreciable color loss compared to thermally processed juices. Inactivation rate of microorganisms increased with increasing treatment time (PEF2). The storage at room temperature the best samples for strawberry juice were the TP and PEF2. While the samples stored under cooling, and treated whether by PEF1 or PEF2 were the best. Also, the storage at cooling temperature was the best with all treatments. We therefore concluded that PEF processing technology for juice products was technically feasible for commercial use. Finally, PEF technology holds great promise as a widely applicable, safe method for strawberry juice.

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