The effect of high voltage electric shock on the quality attribute of carp fish (Cyprinus carpio) meat

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Abstract. Carp is one of the commercial freshwater fish and requires good preservation to maintain the quality of the meat. The non-thermal food preservation method that is still being developed is by using a high voltage electric shock or often called Pulse Electric Field (PEF). The research on the treatment of electric shock using PEF on carp meat has been done. This study aimed to measure the effect of high voltage electric shock on the quality of the carp fish meat. Fresh carp meat fillets were given exposure to electric shock (30 kV, 60 kV, and 90 kV; frequency 50 Hz; pulse width 0.4 s; 600 pulses) when compared with untreated as a control. The data of log total plate count (TPC) and other quality attributes were analyzed by ANOVA and advanced test with Honesly Significance Different (HSD), while non-parametric data were analyzed using Kruskal-Wallis and Mann-Whitney test. The result showed that in untreated meat fish, the log of TPC is higher than treated meat and significantly different (P<0.05) at untreated with the treated samples. The electric shock treatment caused temperature increment from 3.3±0.7°C until 5.6±1.3°C but not significantly different between samples. Moisture content decreased significantly due to high voltage electric shock treatment. pH values ranged from 6.46±0.20 to 6.62±0.23 and were not significantly different between treatment. Meat with electric shock treatment showed significantly different (P<0.05) on weight loss but not in cooking loss. There are no significant differences in hedonic value except tenderness with 60kV. On the microstructure, the treated meat looks more porous than untreated meat. It is indicating that high voltage electric shock processing was effective in the maintenance of carp meat qualities.

1. Introduction

Carp (Cyprinus carpio L) is one of the most commonly cultivated fish species on earth [1], and is often cultivated in ponds, lakes [2] or together with rice plants [3]. Common carp has high contents of essential nutrients, such as vitamins, minerals, polyunsaturated fatty acids, and essential amino acids [4]. However, due to the in physicochemical condition, microbial and enzymatic, the meat of fish is belonging to highly perishable food that has limited self-life. Therefore we need a method to be able to preserve the carp meat.

Equipment that can be used to provide electrical shock is often called the Pulse Electric Field (PEF). PEF technology shows great potential in the inactivation of pathogenic microbes, spoilage microbes or enzymes related to food quality and safety. PEF technology is a non-thermal treatment process that has advantages over conventional heating, especially in preventing loss of sensory and physical properties [5] and this technology is still being developed [6]. The principle of using the non-thermal method (Pulse Electric Field/PEF), based on the application of short pulses at high voltage (20-80 kV / cm) to foodstuffs which are placed between 2 electrodes at room temperature or below for several seconds, the aim is to minimize damage caused by heating. This method is very effective because it can inactivate microorganisms up to 99% without changing the color, odor, and nutritional content [7].

The processing unit of a PEF includes a high voltage wave generator, a treatment site, liquids for handling systems and control equipment or monitors. Depending on the type of PEF, the PEF system has an intensity between 15-50 kV cm⁻¹, pulse width 1-5 µs and a frequency of 50-400Hz [8]. Low-voltage energy from the DC power supply is transformed into high-intensity pulsed fields then stored in capacitors. The high voltage then to be discharged to the target at different electric strengths (20–80 kV cm⁻¹) and times (<1 s), which depend on the purposes to be attained in the food. An excessive increase in voltage will further increase the effect on food [9]. The field strength (Ef) is the most important of all PEF variables [10].

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At present, there is much intensive research about using PEF technology in food. The treatment of PEF can significantly affect the membrane structure of animals, plants or microbial cells, depending on the intensity of the treatment. The use of PEF technology in lamb meat produces a significant difference in changes in the volatile component of meat cuts [11]. PEF with a voltage of 1.4 kV/cm had given significant microstructural changes in beef tissue. The combination of freezing-thawing and PEF increases the softness of the product [12]. The electrical process with PEF does not make the breaking process or agglomeration significantly from b-lactoglobulin or ovalbumin eggs. The lactate dehydrogenase enzyme becomes inactive after the PEF treatment process [13]. The treatment of PEF at room temperature using a moderate electric field (MEF) of 0.5-5kV/cm for 10^2 - 10^3 s resulted in damage to plant tissue, whereas an electric field of 15kV/cm has caused severe damage to the microbial membrane [14]. The treatment of PEF on watermelon juice using high-intensity pulsed electric fields (HIPEF) with a strength of 30-35 kV/cm at a frequency of 50-250 Hz, treatment time of 50-2050µs showed high retention of lycopene and antioxidant capacity of watermelon juice [15]. It has been reported that emerging food processing techniques using electric fields could be extended of the self-life of fish, increasing food preservation, decelerate ATP degradation, protein denaturation, lipid oxidation and microbial growth in tilapia fish meat [16]. Several studies about the effect of pulsed electric field on meat have been done [17, 18, 19, 20].

The application of PEF's electric shock to food will certainly also have an effect on the food, both desired and undesirable changes. Meat and fish products are particularly vulnerable to the detrimental effects of such PEF treatment [21]. Therefore, this study aims to determine the effect of high voltage electric shock on the number of microbes and the several attribute quality of carp meat as a result of the electric shock.

2. Methodology

2.1. Sample preparation

The study was conducted on an experimental laboratory scale. Fish samples were obtained from farmers in the Semarang, Indonesia. Fish samples have a total length of ± 30 cm and weight ± 500 grams per fish. The fish are obtained in a living condition, to ensure that the initial quality of the fish was in good condition and no additional ingredients were used to preserve fish. Fish preparation was carried out at the Fish Processing Product Laboratory, Diponegoro University. The fish was immediately killed, gutted and gilled, washed then filleted for meat. Fish meat was uniformly cut into size 1 x 2 x 4 cm for treatment, with a weight of ± 10 grams per piece. The fish meat was then stored in a refrigerator at ± 4°C for 1 day to wait for the treatment. During preparation, fish meat was always maintained in chilling temperatures.

2.2. High voltage electric shock treatment

The main equipment used in this study was a series of electric shock devices or referred to as PEF (Pulse Electric Field). The device section consists of two main parts, namely the high voltage generator and the chamber for treatment. This high voltage generator was designed to be able to produce voltage strengths from 0 to 100 kV, while the frequency was fixed at 50 Hz with electric current was an estimated 0.032 A, the pulse width of 0.4 s with a square pulse. Some literature shows PEF devices with varying pulse widths [10, 22, 23].

The chamber uses a batch system equipped with two stainless steel conductors measuring 21 x 11 x 0.3 cm arranged in parallel. Stainless steel is a good conductor so that it can conduct electricity properly [31]. The use of plate-shaped electrodes is considered more fitting for solid products and is more efficient because it is possible to produce a more even voltage. Fish meat is placed in a chamber carefully so that fish meat can be exposed to electricity [11]. To ensure that the fish meat is in direct contact with the electrodes, the pieces of fish meat are made uniformly. One indicator that electricity can current through fish flesh is the emergence of lightning from the phase to the ground.

The study was conducted by treating electric shock to fish meat by 30 kV, 60 kV and 90 kV as many as 600 pulses and untreated samples (0 kV) as a control. The treatment of PEF with 600 pulses has more effect on the product compared to the treatment of meat for 300 pulses [18]. After being treated as an electric shock treatment, fish meat was stored in a refrigerator at ± 4°C [12]. Fish meat was stored for a day after treatment to see changes in fish meat after treatment. Then, fish meat samples were prepared to be tested for their quality attributes.
2.3. Temperature changes
Measurement of temperature changes was done by using a Sper scientific direct temperature gauge, 4 channel data-logging thermometer 800024 series. The thermocouple probe was inserted at the center of the meat. Temperature changes were recorded as a difference from the temperature after treatment compared before treatment [20, 24].

2.4. Determination of microbes number
Measuring the total number of bacteria (total plate count; TPC) in carp samples based on SNI (Indonesian National Standart) No. 01-2332.3-2006 [25]. 25 g of the sample was weighed and then put into a sterile blender container, then added 225 ml of Butterfield's phosphate-buffered solution then homogenized. Use a 1 ml sterile pipette, the above suspension was inserted in a 9 ml Butterfield's phosphate-buffered solution, then made of 10⁻², 10⁻³, and 10⁻⁴ by 1 ml of each dilution above is taken using a pipette and then put in sterile Petri. 12-15 ml of nutrient agar which has been cooled to a temperature of 44-46°C was added to each Petri dish which contains the sample solution. After the media has become stable, the Petri dish was then put into a temperature incubator of 35 ± 1°C with the cup upside down. Leave for ± 24 hours and then the cup was removed from the incubator. Then the colonies that grow in each Petri are counted by Handy Tally Counter. The total number of microbes was presented in log form.

2.5. pH value
A 10 g of sample was dissolved with distilled water to a volume of 45 ml. Measurements were made with a pH meter (ADWA AD 1000, Japan). The pH meter has been calibrated with a standard solution of pH 4 and pH 7. The electrodes were dried with a tissue and rinsed with distilled water. The electrodes were inserted into the test sample until the pH meter shows a fixed number. The results of the numbers on the pH meter display were recorded [16].

2.6. Moisture content
Moisture content was measured by oven drying [26]. The analysis was carried out in triplicate.

2.7. Weight loss dan cooking loss
Weight loss was calculated based on the % change in sample weight [18, 27]. Samples were weighed before treatment and immediately weighed again after electric shock treatment using a digital scale. Weight loss (%) was determined based on the difference in sample weight after treatment minus sample weight before treatment divided by sample weight before treatment then multiplied by one hundred. The weighing was done three times and then taking the average for calculation.

Cooking loss measurements were carried out after cooking the sample using a water bath. Before heating, the sample was weighed, and a thermocouple probe was inserted given to measure the center temperature of the meat. Samples were cooked in a water bath with a temperature of 80°C until the samples obtained an internal temperature reached 75°C [29]. After cooked, the sample then cooled and reweighed again after blotting dry with paper towels. The results obtained are then analyzed. Cooking loss (%) was calculated based on the weight of the sample after cooking minus the weight of the sample before cooking, divided by the weight of the sample before cooking multiplied by one hundred.

2.8. Texture measurement
Texture measurements were made on meat that has been cooked in a water bath until its central temperature reaches ± 70°C for 30 minutes [30]. Before cooking, a thermocouple probe was inserted in the center of the meat to checking the temperature. Then, the sample was cooled and stored in the refrigerator overnight. In the morning, the sample was prepared and ready for texture testing. The equipment used for testing was the Texture Analyzer, Brookfield TATX brand. Measurements were repeated three times.
2.9. Hedonic Test

Samples that have been stored overnight then cooked using an electric oven at 180°C until the internal temperature reaches 71°C and looks cooked [18]. Previously the sample has been cut into squares in the size of 1 x 2 x 2 cm. Samples were labeled and presented in small white plates. There were 20 panelists, comprise of men and women and no history of fish meat allergy. The hedonic assessment sheet scores have values from 1 to 9. Existing research, using hedonic tests based on two parameters [18], are tenderness (1 = very tough, 3 = tough, 5 = intermediate, 7 = tender, 9 = very tender) and odour (1= dislike, 5 = neither like nor dislike, 9 = like), whereas in this study, the parameters were added to the taste and appearance parameters with scores ranging from 1 to 9 (1= very dislike, 3= dislike, 5 = neither like nor dislike, 7= like, 9 = very like).

2.10. Microstructure

Samples of carp from each treatment were thinly sliced horizontally, with a size of about 1 x 10 x 20 mm. The sample then dried in the sun drying. After drying, the sample was ready to test with (Scanning Electron Microscope) SEM. Samples were viewed using a JEOL JSM-6510 La Scanning Electron Microscope (JEOL Ltd., Tokyo, Japan) in Laboratorium Terpadu, Diponegoro University, Semarang, Indonesia.

2.11. Statistical analysis

Data were analyzed using SPSS 12 series software. Analysis of variance was performed by ANOVA procedure and advanced test with Honesly Significance Different (HSD) to determine the differences between the samples treatments. The non-parametric data were analyzed using the Kruskal-Wallis and Mann-Whitney test. The data tables were expressed as mean ± SD. P values <0.05 were regarded as significantly different.

3. Results and discussion

3.1. Change of temperature (ΔT) as an effect of electric shock.

The initial temperature of the fish meat is around 20°C. In the untreated sample, the change in meat temperature is caused by the temperature of the sample adjusting to the room temperature, while the temperature change in the treatment sample is due to electric shock during the treatment. Table 1 shows that from the electrical shock treatment that was given, the ANOVA statistical test results showed that there were no significant differences between treatment (P> 0.05). This is likely due to the wide distribution of data or standard deviations in the value of the test results. Although the difference is not significant, the temperature change that occurs during the treatment can affect several other parameters. Data on temperature changes can be found in Table 1.

| Treatment | ΔT (°C) |
|-----------|---------|
| untreated | 3.3±0.7* |
| 30 kV     | 4.2±1.3* |
| 60 kV     | 5.4±1.6* |
| 90 kV     | 5.6±1.3* |

Note:
Values represent mean ±SD from triplicates determination.
The same superscript characterizes no significant differences (p>0.05).

Table 1 shows that sample temperature changes due to treatment and untreated meat ranged from 3.3±0.7°C - 5.6±1.3°C. Temperature difference increased as the treatment intensity (voltage and frequency) increased [24]. The application of low pulse electric fields (LPEF: 2.5 kV, 200 Hz and 20 μs), when treated to beef, can change the temperature by 1.9°C while with high pulse electric fields (HPEF; 10 kV, 200 Hz and 20 μs) changes up to 40°C [22]. When the same system applied to chicken, the results are different, and the average temperature was increased by 17.1°C in HPEF, and an average of 3.1°C in LPEF treated in the same condition [31]. Different parts of the meat and the number of PEF treatments gave a difference in temperature changes [20]. This fact shows that temperature changes due to PEF treatment are very diverse.
3.2. Effect of high voltage electric shock treatment on total plate count (TPC)

Microbes are one of the causes of fish spoilage, so reducing the number of microbes in the sample is expected to minimize the rate of spoilage in fish meat. TPC test results are as shown in Table 2.

Table 2. Log Total Plate Count (TPC) of carp fish meat as an effective electric shock treatment.

| Treatment | Log TPC (CFU/g) | Note: |
|-----------|----------------|-------|
| untreated | 4.60±0.42c     |       |
| 30 kV     | 3.97±0.04b     |       |
| 60 kV     | 3.91±0.08b     |       |
| 90 kV     | 3.76±0.04a     |       |

Note: Values represent mean ±SD from triplicates determination.
Different superscript characterize significant differences (p<0.05).

Based on table 2, the total log number of a microbial colony has decreased with increasing voltage strength exposure. A significant difference (P> 0.05) occurred between the untreated with the treated samples. This shows that electric shock can suppress the number of bacteria. Higher treatment intensities can be used for the inactivation of the microorganism by the irreversible breakdown of the cell membrane [32]. The use of high electric field strengths (10-40 kV/cm) gives an effect for microbial cells resulting in loss of vitality and microbial inactivation. The microbes inactivation also depends on the type of microorganism, the microbial growth stage, the initial amount of microbes and the ionic concentration and conductivity of the suspension [21]. The main factors determining microbial inactivation level during the PEF treatment are electric field strength, treatment time and treatment temperature [33]. If the electric shock voltage is increased by more than 90 kV, likely, the number of microbes will also decrease further.

The number of microbes is still below the provisions of SNI 2729: 2013 concerning the number of microbes in fresh fish [34]. This is due to test the number of bacteria carried out on a sample of carp meat which is kept chill for only one day, so when the storage process is continued, the number of bacteria in a control will likely be more than the number of bacteria in the sample that has been given an electric shock treatment.

3.3. Effect of high voltage electric shock on moisture content and pH.

Table 3 showed that there were significant differences in moisture content parameters (P <0.05), while for pH parameters, there is no significant difference. The data shows that treating a 90 kV voltage electric shock has the lowest moisture content (68.3±2.2%), while the highest in the control which reaches a round 73.8±1.8%.

The difference in moisture content is influenced by the presence of electric shock treatment on the sample. Existing research explained that due to the PEF treatment, the moisture content in beef muscle decreased from 74.6% to 73.4% [27]. If analyzed from the microstructure parameters, it can be seen that the treatment of electric shock results in the existence of small holes that are evenly distributed on the meat, thus allowing free water contained in the meat fish to flow out. This is evident from the results of weight loss tests where fish meat that is given electric shock treatment is lighter than those untreated. Possible by the release of free water, the weight of the meat will also be reduced.

Table 3. Moisture content and pH value of treated and untreated meat of carp fish.

| Treatment | Moisture content (%) | pH       |
|-----------|----------------------|----------|
| untreated | 73.8±1.8c            | 6.62±0.23a|
| 30 kV     | 71.5±1.3b            | 6.50±0.20a|
| 60 kV     | 71.3±1.6b            | 6.46±0.27a|
| 90 kV     | 68.3±2.2a            | 6.54±0.11a|

Note: Values represent mean ±SD from triplicates determination.
Different superscript in same column characterize significant differences (p<0.05).

The results of the research showed that the pH values between treatments were not significantly different (P>0.05). This shows that the electric shock treatment does not affect changes in pH values. The pH value ranges from 6.46 to 6.62, slightly below the average pH of fresh meat which is 5.7 ± 0.03 [19]. The pH value of fresh fish is in the range below neutral to neutral. When the fish dies, the biochemical process that occurs takes place anaerobically which produces lactic acid which can reduce the pH of fish meat. The amount of pH is related to the formation of compounds
which are alkaline during storage and will affect the growth of microbes. In general, fish that are not fresh, meat has a more alkaline pH than fresh fish.

pH is one of the factors that can affect the activity of food enzymes. The pH of fresh fish meat ranges from 6.5-6.8. When pH 6, the activity of cathepsin present in milkfish is almost completely lost, and its activity reaches optimum at pH 3-5 [35]. In the process of fish spoilage, pH changes are significant because they affect the process of autolysis and bacterial growth. The maximum limit of fresh fish pH is 6.8 so pH values obtained in this research are still included in the criteria of good quality.

3.4. Effect of high voltage electric shock on weight loss and cooking loss.

In the weight loss parameter, treating electric shock to meat gave a significant difference in weight change (P<0.05). The smallest change occurred in the untreated sample because there was no treatment except for the waiting period when another sample was given treatment. Based on table 4, change of weight in the untreated sample that occurs allegedly due to the release of free water of meat during that the waiting period. When the sample is placed on a plate, some of the water will be left behind when the sample is removed. This is what causes severe changes to the untreated sample.

Table 4. Weight loss and cooking loss data for carp meat that treated and untreated with an electric shock.

| Treatment | Weight Loss (%) | Cooking loss (%) |
|-----------|----------------|-----------------|
| untreated | 0.15±0.16<sup>a</sup> | 24.08±13.89<sup>a</sup> |
| 30 kV     | 1.79±0.17<sup>b</sup> | 21.74±9.67<sup>a</sup> |
| 60 kV     | 1.41±0.57<sup>b</sup> | 20.98±2.26<sup>a</sup> |
| 90 kV     | 2.64±0.92<sup>b</sup> | 18.46±4.45<sup>a</sup> |

Note: Values represent mean ±SD from triplicates determination. Different superscript in same column characterize significant differences (p<0.05).

The samples have given 30 kV, 60 kV and 90 kV treatments showed that there were significant differences with the controls, but there were no significant (P<0.05) differences between treatments. Weight loss data showed that electric shock treatment affected the physical properties of carp meat. The reason for this reduced weight is due to changes in the physical structure of carp fish. This can be seen in the microstructure parameters of fish meat in fig 1. That is likely that weight loss is due to PEF-induced microstructural changes [10]. The results of existing research showing that treatment of PEF at 2.3 kV/cm caused more significant weight loss than 1.2 kV/cm (p<0.05). PEF treatment induced a ΔT of 22°C significantly affected weight loss of samples post-treatment of beef muscle [27].

When the sample has been treated with electric shock, some free water has been removed from the fish meat, so that when the cooking process is done, only a small amount of free water was removed. This has likely caused no significant difference (P>0.05) in the cooking loss parameter. It is known that the heating process will change the structure of proteins to agglomeration and will release water because the water bonds with the protein become detached. Due to the high voltage electric shock treatment, free water has been released first, so when the fish meat was cooked, the water released was not as much as the untreated sample. Based on the weight of meat after cooking which shows no significant difference (P>0.05), it can be said that electric shock does not have much effect on the weight of meat after cooking (cooking loss). Like research that has been done, the cooking loss (%) of chicken breasts was not affected by the post-treatment aging or treatments PEF but was affected by the interaction of these two parameters [29]. When PEF (0.5 kV dan 10 kV) was treated on beef muscle during the aging period, the results showed that there was no significant difference (P> 0.05) in cooking loss during the treatment [19].

3.5. Effect of high voltage electric shock on meat texture.

The results of the research showed that the texture values in the untreated sample were significantly different from the samples that had been given electric shock treatment. The higher voltage treated causes the texture value to be lower. A low texture value indicates that the force required by the equipment to break down meat is getting smaller so that the meat given to the electric shock treatment is not as hard as the untreated meat.
The texture is an essential parameter for the quality of fish meat [36] and related to consumer acceptance [37]. Changes in fish texture can be caused by damage to the structure of the fish meat tissue which can cause the meat to lose its elasticity and look soft. Damage to fish tissue can be caused by physical, biochemical and microbial activity changes so that there is no power to sustain the structure of the meat compactly. In this study, tissue damage occurred because the structure of the meat had changed due to an electric shock which made fish meat more porous.

3.6. Effect of high voltage electric shock on the hedonic scale.

Table 6 showed that the perception of the panelists on the hedonic test samples' results was almost the same. There was no significant difference in all treatments except in tenderness, where the 60 kV treatment is significantly different from other treatments. Tenderness can indicate the level of fragility of the material being tested.

Table 6. The hedonic test results of carp meat samples were given PEF treatment and were not given treatments.

| Specification | Treatment | untreated | 30 kV | 60 kV | 90 kV |
|---------------|-----------|-----------|-------|-------|-------|
| Tenderness    |           | 6.9 ± 1.21a | 6.5±1.70a | 8.1±1.37b | 7.1±1.65a |
| Odor          |           | 5.7 ± 1.63a | 6.8±1.82a | 6.6±1.79a | 6.5±1.93a |
| Taste         |           | 5.7±1.34a | 6.4±1.31a | 6.4±1.31a | 6.5±1.57a |
| Appearance    |           | 6.3±1.49a | 7.0±1.30a | 7.1±1.37a | 7.1±1.21a |

Note:
- Data taken from 20 panels.
- Different superscript in same column characterize significant differences (p<0.05).

This shows that the high voltage shock treatment does not change people's perception of the treated product. Test samples were considered to be the same both treated and untreated samples, except the item tenderness at an electric shock strength of 60 kV. The results of the research [18] show that 60% of the sensory panelists scored PEF treated samples as tender (≥6.0 points out of 9.0), whereas only 27.5% did so for untreated samples.

3.7. Effect of high voltage electric shock on the microstructure of carp fish meat

From the results of the microstructure, photographs can be obtained information that exposure to high voltage electric shock can change the microstructure of carp meat. Photographs have shown that the structure of untreated meat appears to have a more compact structure, the cell walls are still intact and the tissue is still strong between cells. There are some gaps or holes in some of the meat structures. In the picture on the right, the 30 kV electric shock was seen to give a difference in the form of a wide enough gap, but there were no visible holes in the meat. Besides that, the structure of the meat did not look as compact as untreated meat.
In the photograph of the 60 kV treatment, it was seen that there was slight damage to the cell wall with quite a few visible gaps or holes. The average hole size looks larger than the hole or gap in the untreated sample. Judging from the number of holes, meat samples treated with 60 kV, have more holes than the control. Damage that occurs looks uneven and clustered in several parts of the meat.

In the microstructure image of the meat that given electric shock treatment of 90 kV, it appears that there are many holes of various sizes where are spread almost in all parts of the meat. Meat fiber shows that electric shock treatment gives more texture wrinkles than fish meat without treatment. The structure of the meat at 90 kV treatment looks more porous than the other pictures due to the holes that are evenly distributed in the meat. The existence of this more even hole supports the results of previous test parameters about the amount of free water coming out of the meat given electric shock exposure. Reduced water content, possibly due to the holes that occur, has made it easier for water to flow out of the meat. Water can flow out because the cell wall has been damaged due to electric shock is given. Pulsed electric field (PEF) processing can induce microstructural changes in meat, which can change its functional properties and quality [38]. The application of PEF may have caused an alteration in the myofibrillar structure which led to reduced water holding capacity of the muscle either by physical damage [24].

4. Conclusion

The application of high voltage electric shock to carp meat has a significant influence on some of the quality attributes of fish meat. As a result of high voltage electric shock treatment, an increase in meat temperature value ranges from 3.3 \( \pm \) 0.7°C to 5.6 \( \pm \) 1.3°C but statistically not significantly different. The log number of total plates count of the untreated samples shows a higher value and looks significantly different (P<0.05) than that given by the electric shock treatment. Electric shock treatment does not provide a significant difference in the pH indicator but there is a significant difference in the value of the moisture content. Electric shock treatment gave a significant difference (P<0.05) in weight loss but not in cooking loss. The hedonic test results showed that there were no significant differences in the parameters of appearance, odor and taste, while in the tenderness, there was a significant difference in the 60 kV voltage to other treatments. Electric shock affects some test
parameters but does not affect some other tests. From the data obtained during the research, the electric shock treatment at 30 kV voltage has begun to influence some of the test parameters of the sample.

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