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Effect of the cold plasma and aqueous grape seeds extract on sensory qualities of minced beef

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Abstract

Cold plasma technology has developed in recent decades as a method of processing meat that functions as a bacteriostatic and bactericide, and it is used to treat meat as a non-thermal technique to preserve the sensory qualities of meat. Yet, one of the disadvantages of this approach is lipid oxidation. The purpose of this research is to investigate the effect of aqueous grape seed extract at a (1%) concentration after spraying it onto meat (100 ml/kg) and then treating it with cold plasma (plasma jet) using argon gas at a frequency of 23 kHz, a voltage of 150 kV, a distance of 2 cm, and a time of 5 minutes, as well as to demonstrate the extent of its effect on the sensory evaluation (penal test) of meat at 4 ℃ for 12 days. We separated 100 samples of minced beef into three groups. Group (1)- Control (Con), group (2)- Cold plasma (Cp), group (3)-Grape seeds extract (GSE), and group (4)-Cold plasma mixed Grape seed extract (CP+GSE): Each group has 25 samples, and all parameters were measured. In conclusion, up until the end of the storage period at 4 °C, an analysis of sensory quality revealed that the beef samples treated with GSE and Cp+GSE, respectively, had the highest panel test score.

Keywords: Cold Plasma, Aqueous Grape Seeds Extract, Sensory Quality of Minced Beef

Introduction

People prefer beef because of its high protein content, various essential amino acids, vitamins, and low-fat content. Beef, on the other hand, is susceptible to microbiological contamination and chemical degradation during transportation, storage, and distribution, putting human health at risk [1]. Ground beef is susceptible to bacterial deterioration due to its high nutritional content and high water activity [2, 3]. New sterilization technologies are therefore required. Non-thermal processes improve food safety without sacrificing quality while retaining flavor and aroma. Because of these advantages, alternative food processing techniques are growing in popularity. Plasma is one of these fresh strategies [4,5,6,7].

The use of cold plasma (CP) as a technology in the food sector is a recent discovery. Because it is inexpensive and environmentally friendly, it is gaining popularity [8, 9].

Also, at atmospheric pressure, noble gases like argon are the most frequently used working gases to create non-thermal plasmas [10, 11] .On the other hand, the sensory aspects of meat, such as how it appears, feels, tastes, and smells, have a significant impact on how people accept it and what they choose to purchase [12]. Moreover, Food manufacturers are increasingly using natural preservatives to satisfy consumer demand [13,14]

However, [15] found that sensory parameters such as appearance, color, odor, and overall acceptability were significantly worse in the (cold plasma DBD-treated) pork samples than in the non-treated pork samples. Tenderness, on the other hand, is one of the most important factors impacting meat quality as well as a crucial element influencing consumer perceptions of meat quality. Also, according to Jayasena et al., [16], 0–10 minutes of exposure to DBD-plasma had no effect on the texture of pig butt and beef loin (flexibility, rigidity, cohesiveness and chewiness). Additionally, earlier research employing DBD plasma for chicken breasts revealed a similar conclusion, with the difference that cohesiveness increased considerably with plasma exposure time [17]. Therefore, CP may be used to preserve meat without causing any damage to it.

On the other hand, it was performed a study [18] to look into how cold plasma may be utilized to keep food safe, emphasized the importance of looking into how plasma affected what happened to lipids. The interaction of polyunsaturated fatty acids with reactive oxygen species (ROS) initiates a chain reaction that eventually leads to lipid breakdown and the formation of oxidative rancidity in meat. This process is primarily responsible for meat's gradually decreasing nutritional content and taste [19]. Meat's sensory and functional qualities are significantly impacted by lipid oxidation. Due to factors including fatty acid type, oxygen availability, and the presence of antioxidants, a variety of byproducts are created throughout the process of decomposition [20]. Therefore, several plant extracts have gained popularity as helpful dietary components in recent years. Grape seed extract (GSE) is high in phenolic components such as monomeric flavan-3-ols, procyanidins, and other chemicals, all of which have antimicrobial and antioxidative properties [21, 22]. GSE, on the other hand, has been shown to keep meat fresher for longer dose-dependent periods of time. During 13 days of refrigerator storage, reactive rancidity and volatile compound generation were avoided in vacuum-packed cooked turkey chests [23]. Furthermore, adding essential oils or extracts to zein coatings may improve sensory qualities such as smell, taste, appearance, and feel, as well as antioxidant and antibacterial qualities [24]. Similarly, the addition of GSE to raw, refrigerated ground beef prevented oxidation without altering the color or flavor [25].

Materials and Methods

Aqueous grape seeds extract preparation

Grape seeds were purchased from locally market, transported to the study site, and cleaned with distilled water before being allowed to air dry. It was then dried for eight hours at 40 °C before being grinded using a grinder into a fine powder (Silver Crest, China, Item No.: OG-606). 5 g of the resultant powder was taken out and mixed with 50 ml of almost boiling water after it had reached room temperature. Following a cheesecloth filter, the samples were centrifuged for 10 minutes at 16,000 rpm [26]. However, we modified four steps in this extraction to produce better results:

1. Mixed 30 g of seed powder with 300 ml of water on a magnetic stirrer for 6 hours at a temperature no higher than 40 ° C.
2. The mixture is first filtered through cheesecloth and then through a Whatman No. 1 paper filter.
3. The mixture should be kept in an incubator at a temperature of no more than 40 °C until it is dry.
4. After the mixture has fully dried, 1 g of it is dissolved in 100 ml of normal saline until a concentration of 1% is achieved, and mixed in vortex for 3 minutes.

Preparation of meat sample

Locally minced meat was purchased and transferred to the laboratory in a cool box; the meat was then separated into 4 groups; each containing 25 samples (each sample weighing 25 g). The first group received CP treatment, the second group received GSE treatment, the third group received a mix of CP and GSE treatment, and the fourth group served as a control. Beef samples were stored in sterile polyethylene bags measuring 20 cm 15 cm (Falcon; Sharjah, United Arab Emirates NB-0002) at 4 °C for 12 days, and it was a sensory test on days 0, 3, 6, 9, and 12.

Cold plasma treatment of meat samples

The sole gas utilized in this experiment was argon, and it employed a technique known as plasma jets. The minced meat was subjected to internal voltages of 150 kV, frequencies of 23 KHz, gas flow rates of 5 h/min, plasma bundle lengths of 3 cm, and tube diameters of 0.5 cm. The sample was then placed in a petri dish 2 cm from the tube for 5 minutes. In this study, the frequency and voltage were changed to be different than in previous studies such as Misra [27], yet within the range that kills bacteria and prevent lipid oxidation at the same time.

GSE treatment of meat samples

In this experiment, the spraying method was used. The meat was put on a clean plate inside the hood, and 100 mL/kg of GSE at a concentration of 1% was sprayed on it.

Sensory evaluation (Panel test)

The sensory assessments of minced beef samples are carried out in accordance with the approach developed by some researchers [28, 29]. The samples were put in an oven and baked until the temperature inside reached 230 °C at 30 – 35 min. Subsequently, after being weighed and heated, it was determined that the samples were comparable; panelists then tasted them. Five panelists have had the sensory evaluations at ten in the morning, with enough time between each one to drink water. The sensory evaluation looks at the taste, color, flavor-aroma, tenderness, and overall acceptability of the meat. Each of these qualities is given a score from 1 to 10 to show how good it is.

The following score was given: excellent (nine) very good (eight) good (seven) acceptable (six) bad (initial off-odor and off-taste development) (six); a score of six was considered the minimum acceptable level. After the onset of the first off-odor or off-taste, the product was deemed unsuitable. The examination was completed using the sensory evaluation checklist given in table (1).

Table (1): Information of sensory evaluation

The panellist name:					**Date / /**	
Sample No.	**Color**	**Flavor-aroma**	**Tastes**	**Tenderness**	**Overall acceptance**	**Notes**

Statistical analysis

SAS was used to do statistical analysis of the data (Statistical Analysis System - version 9.1). [30] Two-way ANOVA and Least Significant Differences (LSD) post hoc test were used to determine if there were significant differences between means. Correlation coefficients were also estimated. $P < 0.05$ is considered statistically significant.

$$\mathbf{LSD = 1.414 \times t\,(\boldsymbol{a, d. f.}) \times \sqrt[2]{\boldsymbol{mse/n}}}$$

Results and Discussion

Evaluation of color score

The results demonstrated that various treatments had a substantial impact on the colour scores of beef samples at the six and twelve-day mark in a (Table 2)(Figure 1). On the 6th day, the less-than-desirable colour score reported for CP meat which was 4.92, while the best acceptable score for meat was obtained from GSE, CP + GSE, and CON, with scores of 9.29, 6.92, and 6.20, respectively. At 12th day, meat from Con, Cp, and Cp + GSE had the lowest acceptable colour scores (0.00, 0.00, and 3.52), but meat from GSE had the highest acceptable score (7.02). There were a significant statistical differences ($P< 0.05$) in the colour score across all groups with increasing storage time. The rate of colour score reduction was greatest for the Con and Cp, but it was lowest for the GSE as the storage duration was prolonged. These findings demonstrate that the jet plasma has an effect on the surface of the meat, and that this effect varies with processing time, voltage, and gas. The cold plasma group showed the highest amount of colour variation on day six among all groups. In contrast, The colour test for grape seeds produced the greatest results, with the colour remaining acceptable until the trial was finished in the refrigerator. This suggests that grape seeds have a considerable influence on colour improvement during storage.

Table (2): Effect of treatments and periods of storage on color

Periods groups	zero time	6^{th} day	12^{th} day
con	A9.72±0.02a	B6.26±0.11 b	C0.00±0.00c
CP	A9.72±0.02a	B4.92±0.03c	C0.00±0.00c
GSE	A9.72±0.02a	A9.29±0.03a	B7.02±0.04a
Cp + GSE	A9.72±0.02a	B6.92±0.05b	C3.52±0.04b
LSD	0.30		

Means with a different small letter in the same column are significantly different (P<0.05).
Means with a different capital letter in the same row are significantly different (P<0.05) .
N = 5 , Con = control, Cp = Cold plasma, GSE = Grape seeds extract .

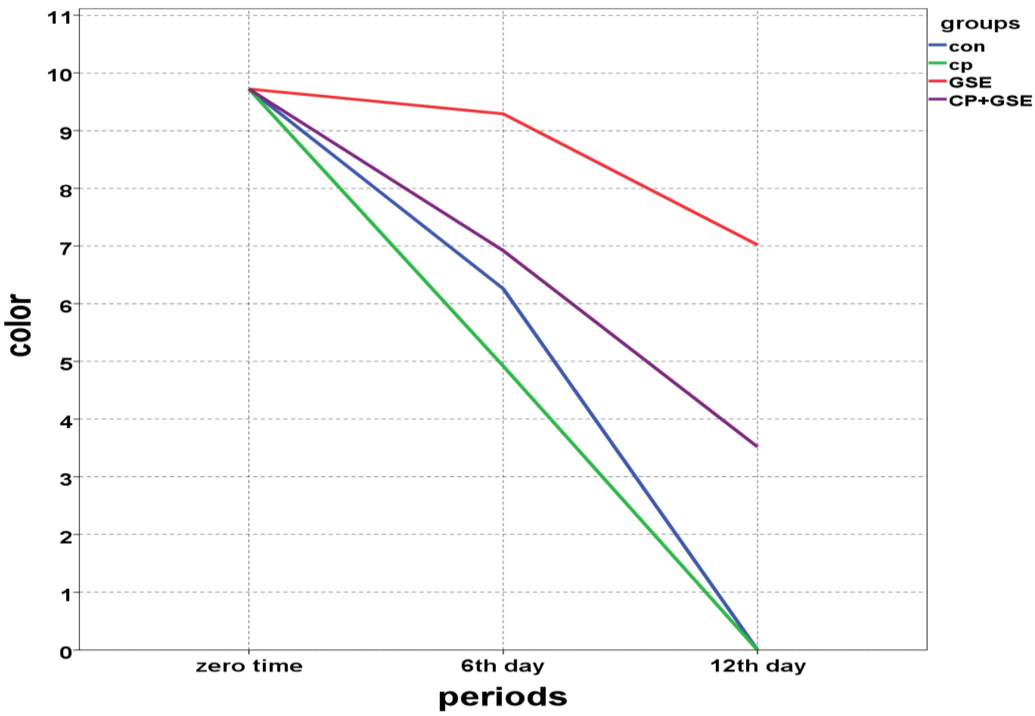

Figure (1): Effect of treatments and periods of storage on color

Evaluation of flavor-aroma score

The Table (3) and Figure (2) demonstrated that utilizing a different processing method had a significant (P<0.05) influence on the flavor score at the 6^{th} and 12^{th} days of storage. The GSE recorded the highest score (7.32),while the lowest score was in Con group, there was only a slight difference between Cp+GSE and Cp (6.68 and 6.48, respectively) on the 6^{th} day. At the 12^{th} day, Con recorded the lowest scores (0.00), while the GSE , CP+GSE, and CP recorded the highest scores (6.58, 6,26, and 4.62

respectively), but the CP and Con groups consider this an unacceptably low score. There were statistically significant differences among all groups (P<0.05) across time periods. The rate of flavor-aroma score decline was greatest for the Con and lowest for the GSE with advanced storage durations.

Table (3): Effect of treatments and periods of storage on flavor-aroma score

Periods groups	zero time	6th day	12th day
Con	A9.59±0.04a	B5.79±0.08d	C0.00±0.00d
CP	A9.59±0.04a	B6.48±0.09bc	C4.62±0.12c
GSE	A9.59±0.04a	B7.42±0.10a	C6.58±0.05a
Cp + GSE	A9.59±0.04a	B6.68±0.08b	C6.26±0.08 b
LSD	0.28		

Means with a different small letter in the same column are significantly different (P<0.05)
. Means with a different capital letter in the same row are significantly different (P<0.05) .
N = 5 , Con = control, Cp = Cold plasma, GSE = Grape seeds extract.

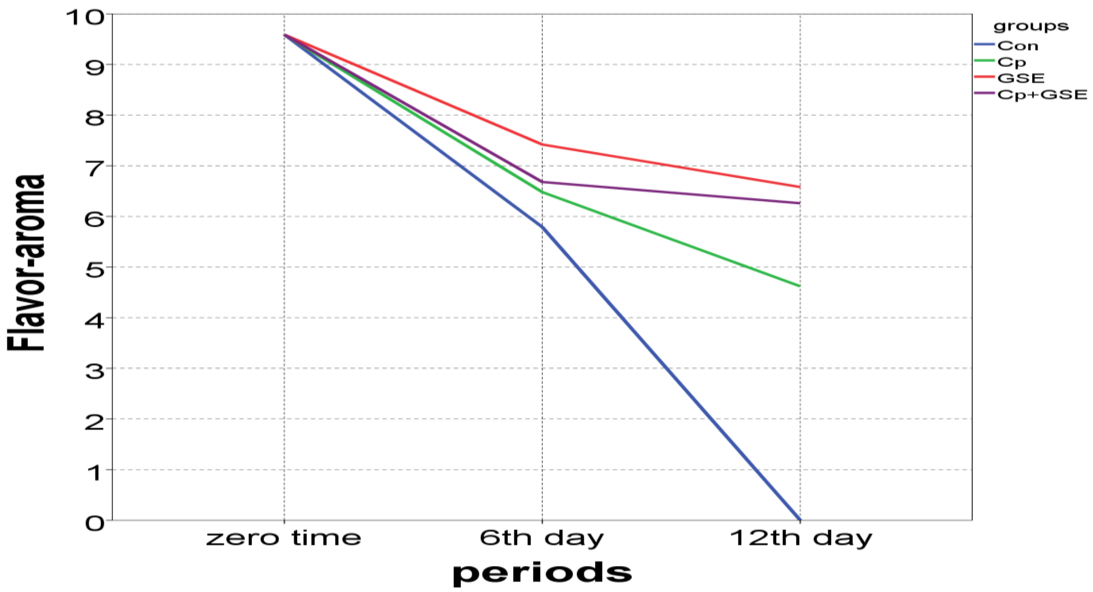

Figure (2): Effect of treatments and periods of storage on flavor-aroma score

Evaluation of tastes score

On the sixth and twelfth days of the period, there were significant increases (P<0.05) among groups, as shown in Table (4) and Figure (3). On the sixth day, the Con group had the lowest taste score (4.72), while the GSE, CP+GSE, and Cp groups showed acceptable scores (7.28, 6.28, and 6.44, respectively). Taste ratings for all groups dropped significantly (P<0.05) with increasing storage durations until the 12th day, but the GSE group recorded the highest score and acceptance until the 12th day.

Table (4): Effect of treatments and periods of storage on tastes score

Periods groups	zero time	6th day	12th day
Con	A9.63±0.04a	B4.72±0.09d	C0.00±0.00d
CP	A9.63±0.04a	B6.44±0.14c	C4.52±0.06c
GSE	A9.63±0.04a	B7.28±0.09a	C6.54±0.05a
Cp + GSE	A9.63±0.04a	B6.82±0.05b	C5.96±0.12b
LSD	0.26		

Means with a different small letter in the same column are significantly different (P<0.05).
Means with a different capital letter in the same row are significantly different (P<0.05) .
N = 5 , Con = control, Cp = Cold plasma, GSE = Grape seeds extract.

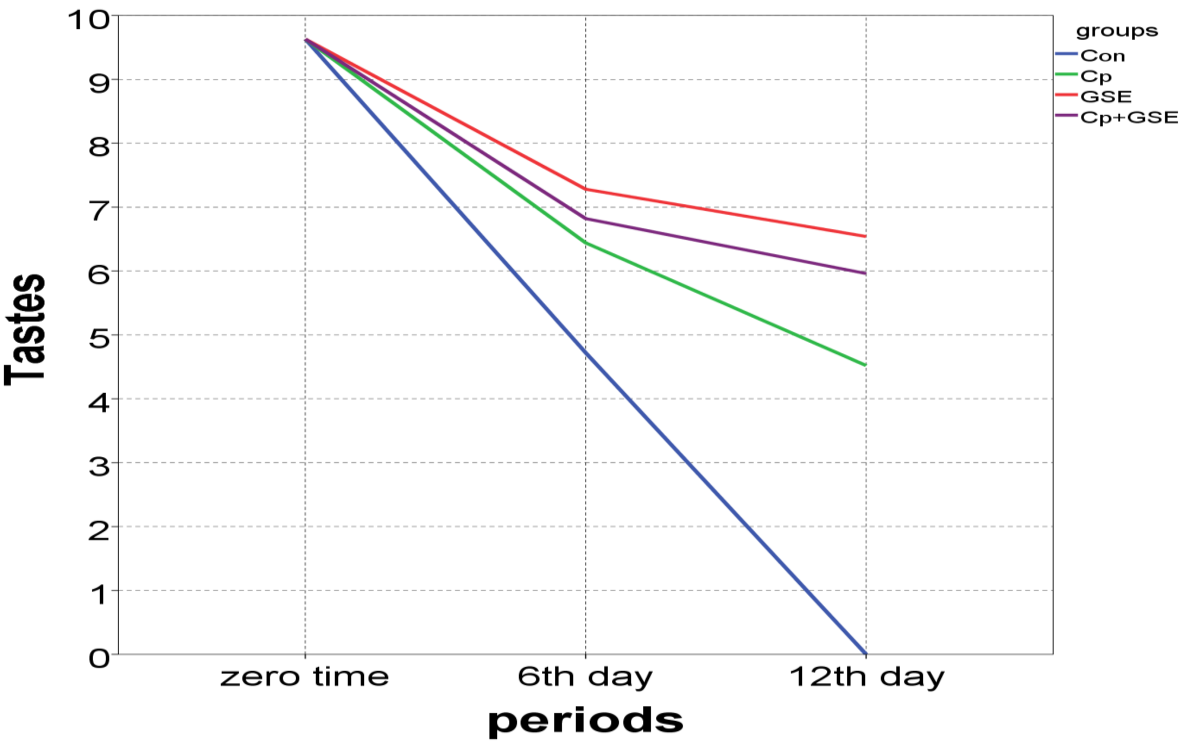

Figure (4): Effect of treatments and periods of storage on tastes score

Evaluation of tenderness score

In Table (5) and Figure (4) results demonstrated that meat samples treated with GSE and Cp+GSE had a significant effect (P<0.05) on the tenderness score at the 6-day (8.34 and 7.16, respectively) among all groups, whereas at the 12-day, only the GSE group recorded an acceptable score (6.05), while all other groups recorded an unacceptable score. But the tenderness score went down for all groups as storage time went up, though the rate of drop was different, with the Cp dropping the most and the GSE dropping the least.

Table (5): Effect of treatments and periods of storage on tenderness score

Periods groups	zero time	6th day	12th day
Con	A9.69±0.02a	B5.72±0.05c	C1.26±0.11c
CP	A9.69±0.02a	B5.26±0.09cd	C1.00±0.00cd
GSE	A9.69±0.02a	B8.34±0.09a	C6.05±0.20a
Cp + GSE	A9.69±0.02a	B7.16±0.10b	C5.18±0.11b
LSD	0.31		

Means with a different small letter in the same column are significantly different (P<0.05).
Means with a different capital letter in the same row are significantly different (P<0.05) .
N = 5 , Con = control, Cp = Cold plasma, GSE = Grape seeds extract.

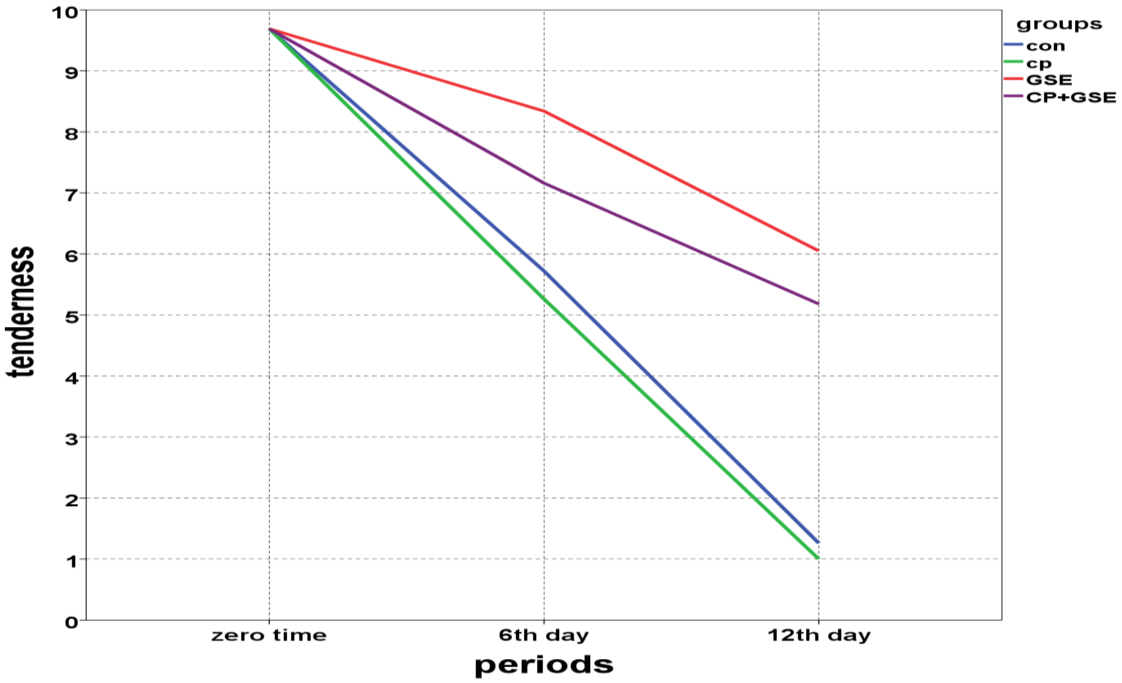

Figure (4): Effect of treatments and periods of storage on tenderness score

Evaluation of Overall acceptance score

As shown in Table (6) and Figure (5), GSE, Cp+GSE, and Cp have a significant (P<0.05) influence on the overall acceptability score after 6 and 12 days of storage. At the sixth day, the best overall acceptability score was observed in meat from GSE, CP +GSE, and Cp, which was 8.10, 6.78, and 6.38, respectively, while the lowest score obtained in Con meat was 5.94. At the 12th day, meat from GSE and Cp+GSE had the greatest overall acceptability (6.41 and 5.45, respectively), whereas meat from Con and Cp had the lowest (both 0.00). The overall acceptance findings revealed that the influence of periods was significant (P<0.05) across all groups. All groups' overall acceptability and advanced periods went down, but the amount of the drop varied.

Table (6): Effect of treatments and periods of storage on overall acceptance score

periods / groups	Zero time	6th day	12th day
con	A9.58±0.03a	B5.94±0.02d	C0.00±0.00c
CP	A9.58±0.03a	B6.38±0.09c	C0.00±0.00c
GSE	A9.58±0.03a	B8.10±0.10a	C6.41±0.17a
Cp + GSE	A9.58±0.03a	B6.78±0.25b	C5.45±0.12b
LSD	0.36		

Means with a different small letter in the same column are significantly different (P<0.05).
Means with a different capital letter in the same row are significantly different (P<0.05) .
N = 5 , Con = control, Cp = Cold plasma, GSE = Grape seeds extract.

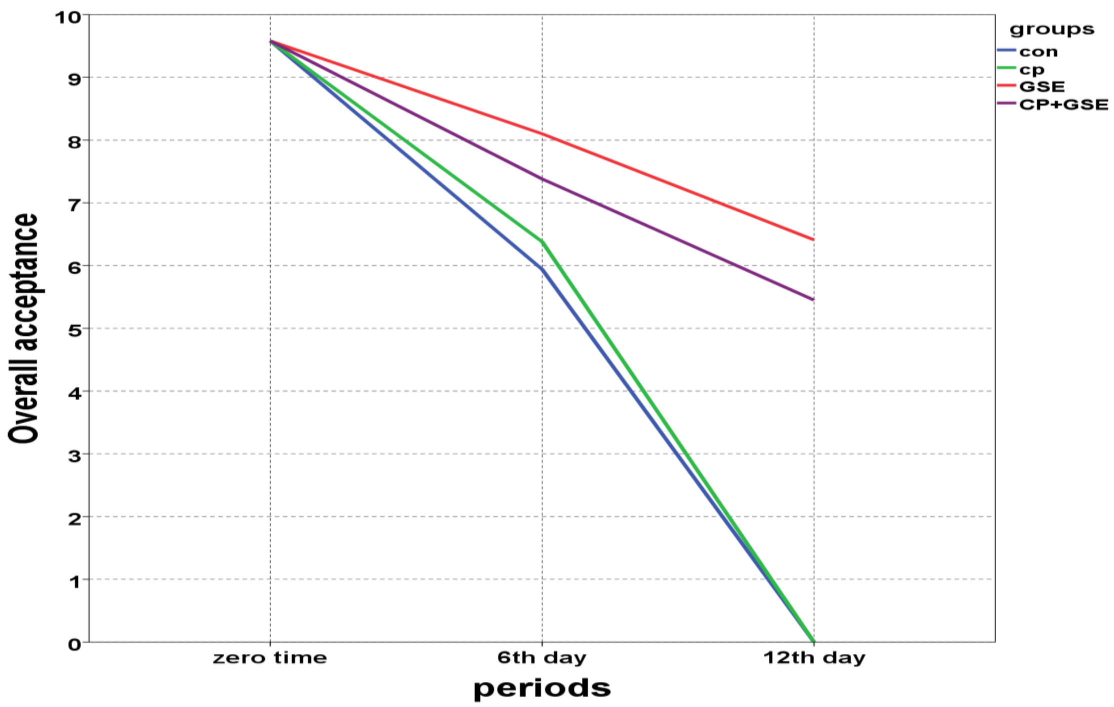

Figure (5): Effect of treatments and periods of storage on overall acceptance score

It can be seen from the Table (7) that there is a real correlation between the sensory qualities in this research. However, the beef treated with Cp had the lowest color and tenderness scores (4.29 and 5.26 respectively), on the sixth day among groups because it loses moisture content and lightness values when exposed to Cp. That the color of the meat has a considerable effect on consumer purchase choices because it is among the most important trait features of meat products, since customers typically use meat color as an indication of meat quality and freshness [30]. The results of this study corroborate the findings of previous researchers, such as Jayasena et al. (2015), the impact on pork and beef samples was only noticeable after being exposed to plasma for at least 5 and 7.5 minutes, respectively ($P<0.05$). Similarly, Kim et al. (15) discovered that DBD treatment reduced sensory measures (such as appearance, color, odor, and acceptance) of raw pork loins ($p<0.05$). But Kim *et al.* (1**5)** and other researchers have found that plasma treatments make pork loin less light, most likely because it loses moisture. In contrast, other researchers, such as Bae et al. (2015) made a discovery; The moisture content (%) values in fresh meats were significantly reduced ($p<0.05$) after treatment to plasma jets (0.5–20 min). However, until 5 minutes after treatment, there was no significant variation ($p>0.05$) in the moisture content (%) of meats treated to plasma jets. Similarly, Kim et al. (2011), found no difference in the moisture (%) of the three types of fresh meat from 0.5 to 5 minutes of plasma treatment. Meat moisture content was found to be correlated to color lightening. In contrast, according to previous research [33] discovered that plasma treatment may successfully inactivate pathogenic bacteria on beef jerky samples while retaining nutritional and sensory attributes.

On the sixth and twelfth days, for all sensory qualities, the GSE-treated meats received the highest scores among all groups. In particular, the color remains red until the 12th day, These results were consistent with prior research, such as [34] who said that the enhanced red of fresh ground beef might be caused by the anthocyanin contained in GSE, depending on the amount employed. Similarly, [35] found that the GSE considerably ($P<0.05$) enhanced the (color, flavor, and overall acceptability scores) during chilled storage of both vacuum-packed and aerobically packaged goods. This may be because GSE inhibits myoglobin oxidation, delaying surface color degradation. The delay in color degradation throughout storage in GSE-treated beef is consistent with the findings [36]. In terms of flavoring, GSE's ant oxidative activity reduces the severity of off-flavor development [37]. Similarly, Ahn et al., [38] observed that adding GSE considerably enhanced the consumer acceptability of pig patties. In contrast, [39]found that the general acceptability of beef products decreased after refrigeration storage. However, researchers such as [40] noticed that GSE affected the odor and color of ground beef samples. The ratings of the overall acceptability of samples treated were considerably higher ($p<0.05$) compared to those of control samples, and the panelists found them to be acceptable.

In the end, because there is currently no research method or motion sensor that can imitate all chewing and biting behaviors or that can measure or recreate human experiences, the participation of humans in sensory evaluations is critical. Because of the complexity of human perception, sensory techniques outperform analytical ways because they enable the examination, synthesis, and assessment of several separate experiences at the same time [41].

The grape seeds extract was able to preserve the sensory qualities in a superior way, followed by the combination (CP + GSE) in comparison to the other treatments on the 12th day at 4°C. On the other hand, the meat's color and tenderness were little altered by the cold plasma dosage compared to the other groups.

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