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EFFECT OF CONVENTIONAL DISINFECTANT ON THE PHYSICOCHEMICAL AND SENSORY QUALITY OF BEEF

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Abstract: *The objective of the study was to determine the physicochemical and sensory quality of beef treated with conventional disinfectants. The studies were conducted in a factorial RCBD with three replications. Factor-A: consist of three (03) treatments: T_0=Control (fresh water); T_1=0.9% NaCl Solution; T_2= Vinegar (5% acetic acid); Factor-B: consists of three (03) times: TM_1=5 minutes; TM_2=10 minutes; TM_3=15 minutes. Physicochemical quality such as moisture, dry matter, crude protein, ash, ether extract, cooking loss, cooking yield, drip loss, pH was determined. Color and sensory quality were also evaluated from treated samples. The results indicated that the incorporation of fresh water, vinegar and 0.9% NaCl solution increased or decreased nutritional properties in raw beef samples. There was a highly significant difference in nutritional and physical qualities among the treatments. 0.9% NaCl solution and vinegar can be used in beef preservation to obtain beneficial result that have better nutritional and physical properties (drip loss, pH, cooking yield, and cooking loss) whilst preserving color and sensory attribute of raw beef. This incorporation could permit a reduction of the contamination and increase shelf life of meat.*

Keywords: *efficacy, disinfectants, proximate, analysis, raw meat*

1. Introduction

Meat is animal flesh that is eaten as food. Humans have hunted and killed animals for meat since prehistoric times. Meat is the main source of protein which is needed for human's body mechanism. It is a very perishable commodity because of its rich nutrients that supports microbial growth [1]. The water activity of beef, approximately 0.99, is suitable for microbial growth thereby supporting proliferation of bacteria that attach and establish themselves on meat [2]. The microbiological contamination of carcasses occurs mainly during removal of hides, evisceration, processing, packaging and storage and distribution at slaughter houses and retailed outlets [3]. Meat is a highly perishable food due to its highly nutritive value for microorganisms. The most common perishable foods to be spoiled are the foods that have high water activity like fruit juices and those that have high amounts of nutrients like milk and milk products, animal products and cereals. Meat is therefore prone to the growth of various microorganisms which causes adverse health effects as well as food spoilage leading to economic loss. Fresh meat is a highly perishable product due to its biological composition and is eaten as food [4]. Hence, utmost care should be taken during processing and storage till its consumption. Meat is the muscle tissue of slaughter animals composed of water, proteins, lipids, minerals and a small proportion of carbohydrates. It is an important source of protein and essential nutrients including iron, zinc, vitamin B_{12} and folic acid. Microbial spoilage of meat is a complex event to which many different bacterial populations can contribute depending on the temperature of storage and packaging conditions. The spoilage can derive from microbial development and consumption of meat

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nutrients by bacteria with a consequent release of undesired metabolites. Many volatile organic compounds (VOCs) can be produced in meat by spoilage microorganisms [5]. The main defects in meat are off-odours and off-flavours, but discoloration and gas production also occur. When a certain microbial association, known as specific spoilage organisms (SSO), predominates, meat rotting during distribution can be viewed as an ecological phenomenon that includes changes in the accessible substrata (such as low molecular components). Ephemeral spoilage organisms (ESO), a much smaller subset of SSO, are actually responsible for meat rotting. These ESO are the result of variables that are either imposed or dynamically persist during, for example, market processing, transit, and storage. In contrast, spoiling is a subjective assessment made by the customer that can be impacted by background and cultural and economic factors, as well as the person's sensory acuity and the degree of change [6]. The common spoilage organisms related to meat are *Brucella, Mycobacterium tuberculosis, Coxiella, Listeria, Campylobacter, beta hemolytic Streptococococci, Y. enterocolitica, Enterpathogenic E. coli, Staphylococcus and Salmonella,* parasites and viruses. These microorganisms produce undesirable quality changes in meats, especially in relation to lactic acid bacteria, a major bacterial group associated with meat spoilage [7]. Microbial growth in meat can result in slime formation, structural components degradation, decrease in water holding capacity, off odors, and texture and appearance changes [8]. a_w meats contain several germs that might cause disease. Bloody diarrhea, excruciating stomach discomfort, and potential consequences for youngsters, the elderly, and those with weakened immune systems are all signs of an *E. coli* infection. Neurological issues and hemolytic uraemic syndrome (HUS) are examples of these consequences [9]. Frequent episodes, bloody diarrhea, prolonged sickness, and hospitalization are all signs of *Vibrio gastroenteritis* [10]. Although raw meat still contains the majority of these pathogens, there are more and more cases of detection in other media [9]. *Salmonella*, for example, is most frequently found in poultry, but it has also been detected recently in eggs, dairy, meat, fresh fruits, and vegetables [11]. Beef, lamb, lettuce, sprouts, fruit juices, vegetables, raw milk, and water have also been reported to contain *E. coli* [9]. A ready-to-eat (RTE) food like chicken nuggets has a far higher risk of disease since many consumers do not re-cook them because they think they are safe. RTE goods have been discovered to contain *Shigella, Salmonella, and E. coli* [12]. Inappropriate handling, leakage, and the globalization of the food market are all potential causes of the rise [9]. Flavor is an important quality attribute which relates to the organoleptic characteristics of meat. Although perception of flavor is a complex phenomenon, odor is the most important single factor contributing to the overall characteristics of flavor. A large number of compounds have been identified in the volatile fraction of red meats and poultry [13]. Animal genetics, premortem and postmortem circumstances, basic muscle chemistry, and several aspects of meat production, packaging, transport, storage, display, and ultimate preparation for eating all play a part in the complicated subject of meat and meat product appearance. Understanding the combined impacts of two basic muscle traits-oxygen consumption and metmyoglobin reduction-is crucial for optimizing meat color life. We now have a clearer understanding of postmortem chilling and pH impacts, packaging atmospheres, antimicrobial interventions, and the safety and quality of

cooked color. We now know the cause of bone discoloration. There are now new color measurement methods available, particularly digital imaging methods, as well as enhanced versions of the current methods. However, there are still issues about the color of meat [14]. One of civilization's main concerns has always been food preservation. These days, we usually rely on refrigeration to keep our food fresh. In the Middle Ages, cooling was another technique for preserving food, but it had drawbacks for obvious reasons. It was necessary to come up with other ways to preserve food, particularly meat. Due to its capacity to reduce pH and induce bacterial cell membrane instability, vinegar is frequently employed as an antibacterial. As the main metabolite, vinegar is known to create citric acid, tartaric acid, and acetic acid [15]. No documented research has been done on the use of vinegar made from agricultural waste to preserve fresh meat. *Salmonella spp., Lysteria monocytogenes, Clostridium botulinum, Campylobacter, Clostridium perfringens, Staphylococcus aureus, Aeromonas hydrophyla,* and *Bacillus cereus* are among the harmful bacteria that are frequently found in fresh meat [16]. During the Middle Ages, salting meat was a frequent practice. This made it possible to transport, store, and preserve beef without refrigeration. Food in Medieval England indicates that "hunting deer according to season, when the meat was at its best, and preparing and storing the venison in larders until needed, in which case heavier salting would be necessary, was a routine procedure on big estates." In large houses, salting venison was so widespread that there were frequently men whose only responsibility was to preserve food. To ensure that the deer were handled and stored appropriately, they would go with the hunters [17]. Fresh meat's biological makeup makes it a very perishable product. The growth and biochemical activity of aerobic, psychrotropic bacterial strains reduce the shelf life of chilled meat under typical, aerobic packaging circumstances. Modified atmosphere packaging, chemical decontamination before packaging, and low dose irradiation after packaging are further control techniques that can be utilized to increase the shelf life of fresh meat [18].

In Bangladesh, one of the most widely consumed animal proteins in the community is beef. Food poisoning is still a common foodborne illness, nevertheless, because the supply of beef and postharvest processing carried out by the slaughterer/butcher, mostly small to medium-sized businesses, is still insufficient to maintain sanitation and hygiene. The following factors affect the quality and safety of frozen meat: quick freezing, constant electricity supply, stable temperature, effective freezer management, appropriate packaging, and cleanliness prior to freezing. Unfortunately, because of limited understanding, awareness, and availability of resources and methods, most of those recommendations have not been adopted in Bangladesh. [19]. When properly frozen with salt and vinegar, fresh meat maintains nearly the same nutritional value. This study aimed to evaluate the effectiveness of commonly used conventional disinfectant like salt and vinegar on the physicochemical and sensory quality of beef.

2. Materials and methods

2.1 Collection of raw materials

Approximately 400 g of beef was collected from retail meat shop in a sterile polythene bag and transported to the laboratory within one hour for analysis.

2.2 Experimental design

The studies were conducted in a factorial RCBD with three replications. Factor-A: consist of three (03) treatments: T_0=Control (fresh water); T_1=0.9% NaCl Solution; T_2=

Vinegar (5% acetic acid); Factor-B: consists of three (03) times: TM1=5 minutes; TM2=10 minutes; TM3=15 minutes. The effect of 0.9% NaCl Solution and Vinegar (5% acetic acid) on the nutritional quality (Proximate analysis, pH, drip loss, cooking yield, cooking loss and sensory analysis) of beef meat was studied.

2.3 Determination of proximate composition

The proximate composition of beef was assessed using the method of [20] in terms of dry matter, ether extract, moisture, crude protein, and ash content. The moisture content was determined by weighing the samples after they had been dried for 24 hours at 75 ℃ in a drying oven (Memmert GmbH & Co.KG). The protein level was estimated using an automatic Kjeldahl nitrogen analyzer, and the fat content was evaluated using the Soxhlet method (VELP Scientifica, Italy). The amount of ash contained was measured using a muffle furnace.

2.4 Measurement of pH

The meat sample was homogenized at 1000 rpm for 30s using a Polytron (Brinkman instruments, New York, NY) blender. A bulb tip combination electrode with a Hanna pH 211 Microprocessor Meters (Hanna Instruments) was used to determine pH.

2.5 Determination of drip loss

Samples of meat were taken from the carcass and weighed right away. The drip loss was calculated using a sample weight of about 80–100 g. To make sure the sample wouldn't come into touch with the bag or the container's supporting mesh, it was first placed in the netting and then suspended in an inflated bag before being carefully sealed. Samples were weighed once more following a 24-hour storage period at cold temperatures. Up to three days later, the same samples were used for additional drip loss assessments; however, the original weight served as the reference point in each instance. Samples were promptly removed from the containers, carefully blotted dry, and weighed at the time of measurement [21].

$$\text{Drip loss (\%)} = \frac{W1-W2}{(W1)} \times 100 \qquad \text{Eq. (1)}$$

Weight of sample (in gram) before thawing = w_1

Weight of sample (in gram) after thawing = w_2

2.6 Determination of cooking yield and cooking loss

Cooking loss was obtained percentage of the difference between before and after cooking weights [22]. At first, fresh samples were cut and weighed (initial weight). The longissimus muscle was further cuts (50 mm thick steaks) and cooked according to a dry heat cooking method. In brief, meat was cooked on a water bath having a beaker with meat opening extending above the water surface. Traditional cooking time was maintained for the determination of cooking loss and cooking yield. It is noteworthy to maintain that 20 minutes were required to reach at 100 ºC temperature. The meat was then taken out from the beaker, blotted dry and weighed. The cooking loss was measured in duplicate, next at 100 ºC temperature, meat sample was cooked for another 10 minutes (total 30 minutes), surface dried and weighed. Finally, at 100 ℃ temperature meat sample was further cooked for 10 minutes (total 40 minutes, traditional cooking time of beef in Bangladesh), surface dried and weighed. Then cooking loss was determined in duplicate [23].

$$\text{Cooking loss (\%)} = \frac{W1-W2}{(W1)} \times 100 \qquad \text{Eq. (2)}$$

$$\text{Cooking yield (\%)} = \frac{(w2)}{(W1)} \times 100 \qquad \text{Eq. (3)}$$

Weight of sample (in gram) before cooking= w_1, Weight of sample (in gram) after cooking= w_2

2.7 Sensory evaluation

The sensory evaluation study was

conducted following the procedures [24]. Six panelists were participated in the sensory evaluation which was carried out at Animal Husbandry Laboratory of Agrotechnology Discipline, Khulna University, Bangladesh. In order to minimize bias, three samples were coded before being evaluated by a sensory panel based on how similar the samples were in terms of appearance, texture, scent, and general acceptability. Panelists were served in their separate locations. A nine-point hedonic scale was employed, with nine being the lowest score (dislike extremely) and one representing the greatest score (like extremely).

2.8 Color analysis

Using a CM (Minolta Chromometer CR-400, Osaka, Japan) with a 1 cm aperture, illuminant C, and a 2-viewing angle, the samples' colors were examined. The equipment was calibrated using a white calibration plate prior to data collection. Redness (a*), yellowness (b*), and lightness (*L**) were assessed. Measurements were made close to each core's center. The surface that was sliced revealed showed color coordinates (*L**, a*, and b**)*. Coordinate b* varied from yellow (+b*) to blue (−b*), and coordinate a* varied from red (+a*) to green (−a*) [25].

2.9 Statistical analysis

Data entry was conducted using Microsoft Excel, and subsequent analysis was performed using Statistix-10 software. The impact of NaCl and vinegar on the physicochemical and sensory quality of beef was assessed through analysis of variance. The Least Significant Difference (LSD) test was used to compare treatment means in cases where significant differences were identified, with $p<0.001$ being considered statistically significant.

3. Result and discussions

3.1 Proximate composition of beef

3.1.1 Moisture content

According to Table 1, moisture content of beef showed a rising rate compared to the control group after the inclusion of 0.9% NaCl solution whereas the vinegar-treated sample was reported as having decreased moisture content which is matched with the findings of [26]. Vinegar was accountable for the loss of the moisture content as meat loses its water holding capacity if the meat's pH is close to the isoelectric pH of the meat proteins. In case of moisture content, the highest value and the lowest value was found in the interaction of T1×TM1 (73.79%) and T2×TM3 (72.03%) respectively. [27] stated that water-holding capacity, or the ability of meat to retain all or a portion of its water, is among the most crucial elemental trait of meat quality. Consequently, weight loss has a crucial financial cost to meat manufacturers and retailers [28]. In case of moisture content, there was no significant differences ($p>0.05$) among the treatments.

3.1.2 Dry matter content

Vinegar-treated samples presented a higher percentage of dry matter content (DM) compared to the samples treated with fresh water (control group) whereas DM content lowered with the inclusion of 0.9% NaCl solution. In the case of moisture content, the highest value and lowest value was found in the interaction of T2×TM3 (27.97%) and T1×TM1 (26.21%) respectively. In addition, increasing storage time showed a decreased rate of dry matter content which is analogous to the findings of both [29] and [30]. In case of dry matter content, there was no significant differences ($p>0.05$) among the treatments.

3.1.3 Crude protein (CP) content

The findings of the Crude protein (CP) were summarized in Table 1. Crude protein content of beef showed a lowered amount when treated with vinegar which suggests that the loss of CP was most likely correlated to the inclusion of vinegar but NaCl treated sample showed an increased amount compared to the control. A similar

trend has been found in the result of [29] where crude protein content increased due to the integration of salt. The highest and the lowest value of crude protein content was found in the interaction of T1×TM2 (21.40%) and T2×TM3 (19.17%) respectively. There was a significant effect of the treatments (p<0.01) on the crude protein (CP) content of beef.

3.1.4 Ether extract (EE)

The findings of the ether extract (EE) are summarized in Table 1. When compared to the control group, the percentage of ether extract (EE) in beef samples treated with vinegar and 0.9% NaCl solutions decreased; the 0.9% NaCl solution treatment produced the lowest value (6.39%). In case of ether extract content, the highest and the lowest value were found in the interaction of T0×TM3 (5.87%) and T1×TM1 (4.18%), respectively. These findings showed a resemblance with the findings of [29], where the inclusion of salt, sugar, and brine in the meat accelerated oxidation. They perceived that lipolysis, which lowers the meat's ether extract level, occurs during curing. There was significant difference (p<0.01) in the Ether Extract (EE) content among the treatments.

3.1.5 Ash

The findings of the Ash contents are summarized in Table 1. In the comparison of the control group with other control groups, ash content increased with the incorporation of vinegar whereas decreased with the incorporation of salt. The results indicated a similarity to those of [31], which stated that the salt's infiltration into the meat and the uptake of moisture from the tissue led to a significant reduction in the ash content of brine-cured beef. The highest and the lowest value of ash content was found in the interaction of T2×TM1 (1.82%) and T1×TM1 (1.05%) respectively. Furthermore, increased storage time also showed decreasing ash value which depicted similar trends found in the result of [29]. The amount of ash in the meat varied significantly (p<0.01) between the treatments.

Table 1.

Proximate composition of beef

Treatment Interaction	Moisture (%)	Dry matter (%)	Crude protein (%)	Ether extract (%)	Ash (%)
T_0×TM_1	72.67±0.07	27.33±0.07	19.99^{d}±0.01	5.45^{b}±0.08	1.53^{bc}±0.05
T_0×TM_2	72.68±0.28	27.32±0.28	20.07^{cd}±0.02	5.67^{ab}±0.04	1.49^{bcd}±0.06
T_0×TM_3	72.42±0.30	27.58±0.30	20.53^{bc}±0.03	5.87^{a}±0.09	1.42^{cd}±0.07
T_1×TM_1	73.79±0.05	26.20±0.05	21.01^{b}±0.03	4.18^{f}±0.05	1.05^{e}±0.03
T_1×TM_2	73.46±0.19	26.20±0.19	21.40^{a}±0.30	4.20^{ef}±0.03	1.39^{cd}±0.01
T_1×TM_3	73.50±0.16	26.49±0.16	21.24^{a}±0.16	4.43^{de}±0.02	1.32^{d}±0.10
T_2×TM_1	72.31±0.03	27.69±0.03	19.88^{d}±0.14	4.89^{c}±0.07	1.82^{a}±0.06
T_2×TM_2	72.41±0.47	27.58±0.47	19.61^{de}±0.24	4.51^{d}±0.15	1.64^{ab}±0.03
T_2×TM_3	72.03±0.06	27.96±0.06	19.17^{e}±0.24	4.60^{d}±0.09	1.79^{a}±0.10
P-Value	0.9344	0.9993	0.0026	0.0040	0.0040
Significant level	NS	NS	**	**	**

*T_0 (fresh water); T_1 (0.9% NaCl solution); T_2 (vinegar); TM_1(5 minutes); TM_2(10 minutes); TM_3(15 minutes) Means with different superscripts within same column differ significantly; NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0. 05*

3.2 Drip loss and pH

Drip loss of beef was analyzed after 24 hours, 48 hours, and 72 hours and the result are presented in Table 2. By analyzing the drip loss after 24 hours, 48 hours, and 72 hours of time it was evident that the amount of drip loss was lower in vinegar-treated samples though over the preservation time

there was an increase in the amount, the value was still lower compared to the control. This finding revealed a resemblance with [32] where acid treatment caused a reduction in drip loss for meat samples. As contrasting to that, the drip loss was higher in the samples treated with 0.9% NaCl solution and over time the amount showed a gradual increase. The highest drip loss was recorded after 72 hours of preservation of the NaCl-treated sample in T1×TM2 (6.93%). This finding also showed a similarity with [32] where drip loss increased for both raw and cooked meat after the incorporation of a certain salt concentration. The drip loss of beef was highly significant (p<0.001) in all the treatments. Regarding the length of display time, the progress of drip loss with time is of major relevance to the retail fresh meat market [33]. [34] claim that while consumers still use appearance as their sole consideration when making a purchasing decision, it has no direct relationship to the quality of food. Color, marbling, and drip loss are the primary sensory criteria. However, according to certain studies, meat with drip loss is disliked by consumers more over the world [35]. Drip loss during product manufacturing, transit, and storage could result in financial losses due to weight loss and decreased yield [36]. In case of drip loss there was highly significant difference (p<0.001) among the treatments. Samples treated with 0.9% NaCl solution showed the highest pH value which presented similarity to the findings of [37] where NaCl-marinated beef exhibited higher pH values in comparison to the control group. By diminishing the links among the tails, NaCl breaks down the thick filament structures, probably facilitating the unveiling of charged and/or hydrophilic groups that were previously concealed. The samples that had been treated with vinegar had the lowest pH in our investigation which is consistent with the findings of [19] where the beef samples treated with vinegar presented a lower pH value. According to [38], the inclusion of acid causes denaturation of meat surface hence vinegar addition lessens the pH of the meat. The highest and the lowest value of pH was found in the interaction of T1×TM1 (6.67) and T2×TM3 (5.12%) respectively. There was no significant difference (p>0.05) in the pH of beef treated with vinegar and salt among the treatments. However, it was also evident that the pH value dramatically dropped throughout the course of frozen storage. The formation of acid from the fermentation of meat's carbohydrates, binders, salt, and spices may be to blame for the pH drop.

3.3 Cooking loss and cooking yield

The findings of the cooking loss and cooking yield are summarized in Table 3. The cooking loss of the samples was analyzed after 20, 30, and 40 minutes of time. After 20 minutes cooking loss showed a declining rate in vinegar-treated samples whereas NaCl-treated samples showed a rising rate of cooking loss. The highest and the lowest cooking loss was found in the interaction of T1×TM1 (49.08%) and T1×TM3 (35.13%), respectively. However, with the advancement of storage time, both vinegar and 0.9% NaCl solution-treated samples displayed a higher percentage of cooking loss compared to the control, corresponding with the findings of [19] where the control group experienced the highest cooking loss (no vinegar added) and in the findings of [39] where reduction of cooking loss was obtained with the incorporation of both salts alone or in combination. In the case of cooking loss, there was no significant (p>0.05) difference among the treatments. [40] remarked that cooking duration had a strong association with cooking loss compared to cooking temperature. Juiciness and cooking loss have been demonstrated to be negatively associated in beef, indicating that a high

cooking loss leads in low juiciness [41]. [42] stated that, consumer contentment is correlated with the three components of cooked beef palatability: tenderness, juiciness, and flavor.

Table 2.

Drip loss of beef

Treatment Interaction	pH	Drip loss –Day 1(%)	Drip loss –Day 2(%)	Drip loss –Day 3(%)
$T_0 \times TM_1$	6.34±0.03	3.95^{c}±0.03	4.26^{c}±0.06	5.06^{e}±0.03
$T_0 \times TM_2$	6.27±0.13	3.67^{d}±0.09	4.09^{d}±0.04	5.20^{d}±0.05
$T_0 \times TM_3$	6.32±0.01	3.78^{d}±0.02	4.16^{cd}±0.05	5.29^{d}±0.04
$T_1 \times TM_1$	6.67±0.007	4.56^{b}±0.06	5.24^{b}±0.06	6.75^{b}±0.03
$T_1 \times TM_2$	6.59±0.04	5.05^{a}±0.02	5.43^{a}±0.02	6.93^{a}±0.06
$T_1 \times TM_3$	6.52±0.02	5.01^{a}±0.05	5.38^{a}±0.09	6.27^{c}±0.05
$T_2 \times TM_1$	5.28±0.05	3.30^{f}±0.09	3.66^{e}±0.03	4.94^{f}±0.05
$T_2 \times TM_2$	5.16±0.03	3.37^{ef}±0.06	3.68^{e}±0.02	4.50^{g}±0.03
$T_2 \times TM_3$	5.12±0.04	3.49^{e}±0.05	3.71^{e}±0.05	4.94^{g}±0.02
P-Value	0.6655	0.0000	0.0073	0.0000
Significant Level	*NS*	***	**	***

*T_0 (fresh water); T_1 (0.9% NaCl solution); T_2 (vinegar); TM_1(5 minutes); TM_2(10 minutes); TM_3(15 minutes) Means with different superscripts within same column differ significantly; NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

Table 3.

Cooking yield and cooking loss

Treatment Interaction	Cooking loss – 20 Minutes (%)	Cooking yield – 20 Minutes (%)	Cooking loss – 30 Minutes (%)	Cooking yield – 30 Minutes (%)	Cooking loss – 40 Minutes (%)	Cooking yield – 40 Minutes (%)
$T_0 \times TM_1$	35.41±0.04	64.59±0.04	35.47±0.03	64.53±0.03	35.50±0.02	64.50±0.02
$T_0 \times TM_2$	35.25±0.05	64.75±0.05	35.37±0.02	64.62±0.02	35.48±0.05	64.51±0.05
$T_0 \times TM_3$	35.13±0.02	64.87±0.02	35.33±0.01	64.67±0.01	35.39±0.05	64.60±0.05
$T_1 \times TM_1$	42.12±0.04	57.88±0.04	45.49±0.05	54.51±0.05	49.08±0.06	50.92±0.06
$T_1 \times TM_2$	42.13±0.06	57.87±0.06	45.41±0.03	54.59±0.03	49.00±0.09	51.00±0.09
$T_1 \times TM_3$	42.04±0.03	57.96±0.03	45.37±0.05	54.63±0.05	49.06±0.03	50.94±0.03
$T_2 \times TM_1$	37.79±0.04	62.20±0.04	40.29±0.02	59.71±0.02	45.86±0.09	54.14±0.09
$T_2 \times TM_2$	37.71±0.05	62.29±0.05	40.20±0.04	59.80±0.04	45.85±0.09	54.15±0.09
$T_2 \times TM_3$	37.60±0.06	62.40±0.06	40.15±0.02	59.85±0.02	45.72±0.06	54.28±0.06
P-Value	0.2155	0.2157	0.9941	0.4130	0.1463	0.8472
Significant Level	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

*T_0 (fresh water); T_1 (0.9% NaCl solution); T_2 (vinegar); TM_1(5 minutes); TM_2(10 minutes); TM_3(15 minutes) Means with different superscripts within same column differ significantly; NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

3.4 Sensory evaluation

The findings of the taste panel's assessment of the beef related to appearance, aroma, and texture after five hours of preservation are reported in Table 4. Aroma score of the present findings was increased with the incorporation of vinegar which is matched with the findings of [19]. The highest value of aroma score was found in T2×TM1 (6.67). Appearance score was increased with the incorporation of salt. Beef samples treated with 0.9% NaCl solution were chosen as the most desirable appearance and the highest value of appearance score was found in T1×TM1 (3.67). The acidic content of vinegar penetrates the meat and makes it tender. The incorporations of salt increased the appearance, aroma and

texture of beef. The highest value of texture score was found in T1×TM1 (7.05). Color, flavor, juiciness and perhaps texture are the major factors that motivate acceptability of any food, meat inclusive.

Table 4.

Sensory evaluation

Treatment Interaction	Appearance	Aroma	Texture
$T_0 \times TM_1$	$2.71^{b} \pm 0.05$	3.00±0.05	3.33±0.07
$T_0 \times TM_2$	$2.80^{b} \pm 0.06$	2.97±0.03	3.28±0.06
$T_0 \times TM_3$	$2.63^{b} \pm 0.04$	3.01±0.02	3.30±0.02
$T_1 \times TM_1$	$3.67^{a} \pm 0.09$	3.63± 0.06	7.05±0.03
$T_1 \times TM_2$	$3.54^{a} \pm 0.10$	3.64±0.03	7.00±0.10
$T_1 \times TM_3$	$3.68^{a} \pm 0.05$	3.67±0.03	7.01±0.05
$T_2 \times TM_1$	$2.11^{d} \pm 0.03$	6.67±0.04	3.33±0.02
$T_2 \times TM_2$	$2.27^{c} \pm 0.07$	6.65±0.03	3.33±0.05
$T_2 \times TM_3$	$2.33^{c} \pm 0.05$	6.65±0.04	3.31±0.05
P-Value	0.03	0.95	0.99
Significant Level	*	NS	NS

*T_0 (fresh water); T_1 (0.9% NaCl solution); T_2 (vinegar); TM_1(5 minutes); TM_2(10 minutes); TM_3(15 minutes) Means with different superscripts within same column differ significantly; NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

3.5 Color analysis

The results of the color profile evaluation on the various flame attributes such as lightness, redness and yellowness of beef preservation are summarized in Table 5. After five hours of preservation, beef samples treated with vinegar exhibited the most desirable *L** (48.54%), which concurs with the findings of [19], who also found that vinegar-treated beef samples showed the superior color. Introducing salt and fresh water makes samples appear more attractive in redness.

But there was little significant change in color in respect of all the treatments.

Table 5.

Color analysis of beef

Treatment Interaction	**L*(Lightness)**	**a*(Redness)**	**b*(Yellowness)**
$T_0 \times TM_1$	$43.69^{e} \pm 0.16$	$14.84^{a} \pm 0.31$	5.37±0.11
$T_0 \times TM_2$	$43.27^{e} \pm 0.04$	$13.83^{bc} \pm 0.10$	5.26±0.006
$T_0 \times TM_3$	$43.99^{e} \pm 0.03$	$14.31^{ab} \pm 0.03$	5.51±0.006
$T_1 \times TM_1$	$45.69^{cd} \pm 0.26$	$12.93^{de} \pm 0.37$	4.80±0.10
$T_1 \times TM_2$	$45.15^{d} \pm 0.19$	$13.22^{cd} \pm 0.07$	4.72±0.05
$T_1 \times TM_3$	$45.60^{cd} \pm 0.29$	$13.19^{cd} \pm 0.92$	5.06±0.05
$T_2 \times TM_1$	$48.54^{a} \pm 0.003$	$12.45^{ef} \pm 0.31$	6.64±0.05
$T_2 \times TM_2$	$46.10^{c} \pm 0.57$	$12.01^{fg} \pm 0.28$	6.46±0.17
$T_2 \times TM_3$	$47.32^{b} \pm 0.16$	$11.62^{g} \pm 0.03$	6.50±0.06
P-Value	0.01	0.05	0.13
Significant Level	**	*	NS

*T_0 (fresh water); T_1 (0.9% NaCl solution); T_2 (vinegar); TM_1(5 minutes); TM_2(10 minutes); TM_3(15 minutes) Means with different superscripts within same column differ significantly; NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

3.6 Correlation matrix of selected nutritional properties of beef

The results of Pearson's correlation coefficients correlation analysis among selected physical and nutritional properties (Moisture, dry matter, crude protein, ether extract, ash) of beef are presented in Table 6. A significant (p<0.05) positive correlation was found between moisture and crude protein(r=0.0442). We also found significant negative correlation between dry matter and crude protein(r=-0.0381). There was non-significant (p>0.05) positive correlation between dry matter and ether extract (r=0.5232); dry matter and ash(r=0.8836).

Table 6.

Pearson correlation coefficients among selected nutritional properties of beef

Parameters	1	2	3	4
1. Moisture				
2. Dry matter	-1.0000^{NS}			
3. Crude protein	0.0442*	-0.0381*		
4. Ether extract	-0.5176^{NS}	0.5232^{NS}	0.8153^{NS}	
5. Ash	-0.8845^{NS}	0.8836^{NS}	-0.2977^{NS}	0.2194^{NS}

*NS= non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

3.7 Correlation matrix of selected physical properties of beef

The results of Pearson's correlation coefficients analysis among selected physical properties of beef are presented in Table 7. The majority of the parameters showed non-significant (p>0.05) association with one another. We found non-significant positive correlation among the parameters: pH and drip loss after 48(r=0.7969); pH and drip loss after 72(r=0.8340); pH and drip loss after 24(r=0.7738); pH and cooking loss after 20 minutes (r=0.3482); pH and cooking loss after 30 minutes (r=0.2124); drip loss after 24 hours and drip loss after 48 hours(r=0.9881); drip loss after 24 hours and drip loss after 72 hours (r=0.9280); drip loss after 24 hours and cooking loss after 20 minutes (r=0.7838); drip loss after 72 hours and cooking loss after 20 minutes (r=0.8195); drip loss after 48 hours and cooking loss after 30 minutes (r=0.7014); cooking loss% after 20 minutes and cooking loss after 30 minutes (r=0.9898); cooking loss after 30 minutes and cooking loss after 40 minutes (r=0.9505); We also found non-significant negative correlation between pH and cooking loss after 40 minutes(r=-0.1011).

Table 7.

Pearson correlation coefficients among selected physical properties of beef

Parameters	1	2	3	4	5	6
1. pH						
2. Drip loss after 24 h	0.7969^{NS}					
3. Drip loss after 48 h	0.8340^{NS}	0.9881^{NS}				
4. Drip loss after 72 h	0.7738^{NS}	0.9280^{NS}	0.9580^{NS}			
5. Cooking loss after 20 minutes	0.3482^{NS}	0.7838^{NS}	0.7947^{NS}	0.8195^{NS}		
6. Cooking loss after 30 minutes	0.2124^{NS}	0.6939^{NS}	0.7014^{NS}	0.7394^{NS}	0.9898^{NS}	
7. Cooking loss after 40 minutes	-0.1011^{NS}	0.4488^{NS}	0.4470^{NS}	0.5073^{NS}	0.8968^{NS}	0.9505^{NS}

*NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

3.8 Correlation matrix of selected color and sensory properties of beef

Table 8 displays the findings of the Pearson's correlation coefficient investigation between a few chosen beef color and sensory characteristics. There was a substantial (p<0.01) positive connection between texture and lightness (r=0.0037). A non-significant (p>0.05) positive association was also seen between appearance and texture (=0.9318), appearance and redness (r=0.2593), aroma and lightness (r=0.8694), aroma and yellowness (r=0.8788), and lightness and yellowness (r=0.6517). Texture and redness had a significant negative connection (p<0.05) (r=-0.0329). Additionally, there was a non-significant negative connection between appearance and yellowness (r = -0.9088), aroma and redness (r = -0.8752), texture and yellowness (r = -0.7267), scent and texture (r = -0.3438), and appearance and lightness (r = -0.3350).

Table 8.

Pearson correlation coefficients among selected sensory properties and color of beef

Parameters	1	2	3	4	5
1. Appearance					
2. Aroma	-0.6384^{NS}				
3. Texture	0.9318^{NS}	-0.3438^{NS}			
4. L*(Lightness)	-0.3350^{NS}	0.8694^{NS}	0.0037**		
5. a*(Redness)	0.2593^{NS}	-0.8752^{NS}	-0.0329*	-0.8292^{NS}	
6. b*(Yellowness)	-0.9088^{NS}	0.8788^{NS}	-0.7267^{NS}	0.6517^{NS}	-0.9088^{NS}

*NS= Non-significant, ***=p<0.001, **=p<0.01; *=p<0.05*

4. Conclusions

The qualitative parameters of beef, such as moisture content, dry matter, crude protein, ether extract, ash content, drip loss, pH, cooking loss, sensory evaluation, and color profile, were examined in this study in relation to vinegar and a 0.9% NaCl solution. The research brought to light a number of noteworthy conclusions: When samples were treated with vinegar, their moisture content decreased, but when samples were treated with NaCl, it increased. The fact that there were no appreciable variations in the groups' moisture content for either treatment suggests that vinegar had a major impact on the meat's ability to retain water. In contrast to samples treated with NaCl, samples treated with vinegar had a greater dry matter content. Dry matter content did not differ significantly between treatments, while storage duration did gradually decrease. The inclusion of NaCl increased the crude protein content, while vinegar treatment reduced it, with significant differences observed among treatments. Both vinegar and NaCl treatments led to a decrease in ether extract content, with the lowest value found in NaCl-treated samples. Significant differences were found between treatments, with salt promoting lipolysis during curing. Vinegar increased ash content, while salt decreased it, likely due to salt's moisture absorption properties. Significant differences in ash content were observed among the treatments.

Vinegar-treated samples exhibited lower drip loss, while NaCl treatment resulted in higher drip loss over time, with significant differences across treatments. This underscores vinegar's role in reducing moisture loss during storage. NaCl-treated beef exhibited higher pH values, while vinegar-treated samples had lower pH, confirming the impact of acidity on meat denaturation. No significant difference was observed in pH values across treatments.

The vinegar treatment resulted in a decrease in cooking loss, while NaCl treatment increased cooking loss, although no significant differences were found between treatments. Vinegar improved aroma scores, while NaCl enhanced appearance and texture, indicating that both treatments improved specific sensory attributes. The highest scores for texture and appearance were associated with NaCl treatment. Vinegar-treated samples showed superior lightness, while salt and water treatments enhanced redness. Overall, color changes were minimal but highlighted the impact of treatment on beef appearance.

In conclusion, vinegar and 0.9% NaCl solution both significantly affected beef quality, particularly in terms of sensory attributes, pH, and drip loss. These findings suggest that both vinegar and NaCl treatments can be utilized to improve the quality and shelf-life of beef, with vinegar being more effective in reducing drip loss and enhancing aroma, and NaCl improving texture and appearance. Further research with extended storage periods and varied conditions could provide deeper insights into their long-term effects on meat preservation.

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6. References

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