Meat Research
Vol 3, Issue 6: 1-7, Article 74
ISSN: 2790-1971
https://doi.org/10.55002/mr.3.6.74
http://www.bmsa.info/meatresearch

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Keywords:

Distilled Water
NaCl
Vinegar
Beef
Preservatives

Article Info:

Received: 17 November 2023
Accepted: 21 December 2023
Published online: 31 December 2023

Research Article

Comparative analysis of traditional preservatives for raw beef

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Abstract

Butchers in developing countries face the challenge of finding affordable disinfectants for their products which are not associated with adverse impacts on quality and shelf life. As an affordable option, traditional disinfectants, vinegar, and NaCl solutions have been renowned since ancient times, which led this study to focus on assessing the nutritional and sensory quality of raw beef treated with conventional disinfectants during processing. In a completely randomized study design, the fresh raw beef samples were split into three treatments: T_1 as control (water), T_2 (vinegar), and T_3 (0.9% NaCl solution), and their effects on nutritional and sensory quality (color, appearance, aroma, and texture) were studied. It was found that there was a decrease in the value of moisture content, crude protein, and ether extract ($p<0.001$) associated with the incorporation of vinegar, whereas the dry matter and ash content ($p<0.001$) increased. On the other hand, apart from moisture, the other parameter seemed to decrease with the infusion of salt. With more storage time, the pH and dry matter content both considerably dropped ($p<0.001$), and a significant ($p<0.001$) color change was seen. A significant association ($p<0.05$) was found between drip loss and cooking loss after 24 hours. In conclusion, a certain level of vinegar can be used in beef preservation for better nutritional and textural properties.

Introduction

Beef ranks third in terms of consumption, after pig and poultry, which account for 38% and 30%, respectively of global meat production (Raloff, 2003). In Bangladesh, the total livestock population is 432.4 million, of which 9.26 Mmt meat is produced yearly (DLS, 2022). Due to the presence of high-quality nutrients, the variety of presentation options, and the highly regarded sensory qualities, meat, and meat products are a class of food products that are frequently consumed by humans (Grasso et al., 2014; Rahman et al., 2020). Animal genetics, pre- and postmortem circumstances, basic muscle chemistry, and other aspects of meat processing, packing, transport, storage, presentation, and final dietary preparation all have a role in the final look of meat and meat products (Mancini and Hunt, 2005; Disha et al., 2020).

Due to its chemical makeup, physicochemical features, improper processing and storage procedures, raw meat and its derivatives are susceptible to spoilage (Doulgeraki et al., 2012; Nychas et al., 2008). Researchers have attempted to address this issue by incorporating various techniques including chilling, curing, drying, and irradiation as well as by adding natural antioxidants and antimicrobial agents (Akhter et al. 2009; Haque et al., 2017; Jahan et al., 2018). In one study Kim et al., (2021) stated that the quality and sensory aspects of meat products, like saltiness, color, juiciness, and texture are enhanced with the addition of salt because salt eradicates myofibrillar proteins and creates the ideal texture (Kim et al., 2021; Lee and Chin, 2019; Laranjo et al., 2017). Similarly, Liu et al., (2020) discovered that salt substitutes altered the sensory profile of beef by elevating the aroma. Furthermore, Baublits et al., (2006) reported palatability improvements in beef muscles while reducing the color degeneration induced by salt amplification. In another study, Islam et al., (2009) stated that brine curing is an effective process for beef preservation. Correspondingly, Sarker et al., (2021) concluded in the study that vinegar is efficient in short-term preservation. In addition, Tabiy and Soliman (2011) summarized that the usage of acetic acid in beef ensures safe and high-quality meat. Likewise, Ebaid (2016) discovered that the sensory quality of beef increases with the addition of acetic acid.

Consumers' expectations about food quality have grown in recent years, especially in connection to how healthy they consider foods to be. Meat products are not exempt (Teixeira and Rodrigues, 2021; Parvin et al. 2017). In Bangladesh, there is an exponential increase in demand for meat and its derivatives (Azad et al. 2022; Hashem et al., 2023). Nevertheless, scanty research has been performed in Bangladesh to perceive the quality of raw meat through conventional disinfectants. Therefore, the purpose of the current study is to evaluate the nutritional and sensory quality of beef when treated with vinegar and salt solution during processing.

Materials and Methods

Study area of the experiment

The study was conducted at the Animal Husbandry Laboratory of the Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh.

Collection and Preparation of samples

Approximately 400g of beef was collected from the local market in a zipper bag; and salt and vinegar were collected from a super shop in Khulna City, Bangladesh. The samples were refrigerated at a temperature of 4ºC. All beef meat samples were treated with fresh water (T_1), vinegar (T_2), and 0.9% NaCl Solution (T_3). For preparing 0.9%NaCl solution 0.45g weighed NaCl were added into 500 ml distilled water.

Meat quality assessment

The proximate composition of the longissimus muscle of beef was determined (AOAC, 2002).

Color analysis

A boneless beef muscle section 12 cm thick was removed from longissimus muscle cuts for objective color evaluation (L*, a*, b*, c*, and h*). A CM (Minolta Chromameter CR-400, Osaka, Japan) with a 1 cm aperture was used to collect readings close to the center of each core (Hunter Lab, 1996).

pH analysis

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 for pH determination.

Determination of cooking yield and cooking loss

Freshly cut (50 mm thick longissimus muscle cuts) and weighted samples were cooked in a water bath by dry heat cooking method for 20 minutes at 100^{o}C temperature. After that, the flesh was dried off and weighed. Next at 100^{o}C temperature meat sample was cooked for 10 minutes each time (total of 30 minutes), surface dried, and weighed. Then at 100^{o}C temperature meat sample was cooked for 10 minutes (total of 40 minutes), surface dried, and weighed. Then cooking loss was measured in duplicate (AMSA, 2015).

Determination of drip loss

A beef carcass sample weighing around 100g was suspended in an inflated bag after being put on netting and was again subjected to weighing following 24 hours of chilling. Up to three consecutive drip loss assessments were made utilizing the same samples; however, each time the initial weight served as the standard. Samples were promptly withdrawn from the containers when the measurement was performed, carefully patted dry, and weighed (Honikel, 1998).

Sensory evaluation

Following Peryam and Piligrim's methodology (Peryam and Pilgrim, 1957), an assessment of the sensory properties was carried out.

Data analysis

All acquired data were compiled and evaluated by employing the General Linear Model (GLM) procedures of SAS Institute (SAS, 1996) with p<0.05 level of significance. The Duncan's Least Significance Difference test was carried out to determine the significant difference among treatment groups.

Results and Discussion

Table 1. Proximate analysis of beef

Parameter	Treatment			p value	Sig. level
	T_1	T_2	T_3		
Moisture	$73.06^{b}\pm0.03$	$71.48^{c}\pm0.03$	$75.34^{a}\pm0.03$	<.0001	***
DM	$26.94^{b}\pm0.03$	$28.45^{a}\pm0.03$	$24.53^{c}\pm0.03$	<.0001	***
EE	$10.05^{a}\pm0.04$	$8.25^{b}\pm0.06$	$6.39^{c}\pm0.06$	<.0001	***
Ash	$8.27^{b}\pm0.06$	$12.23^{a}\pm0.06$	$6.23^{c}\pm0.06$	<.0001	***
CP	$26.79^{a}\pm0.06$	$22.29^{b}\pm0.06$	$15.32^{c}\pm0.06$	<.0001	***

T_1 (fresh water); T_2 (vinegar); T_3 (0.9% NaCl solution); DM=Dry matter; EE=Ether extract; CP=Crude protein; Means with different superscripts within same row differ significantly; NS= Non significant,***=p<0.001, **=p<0.01; *=p<0.05.

Dry matter content

According to Table1, the moisture content of the sample exhibited an upward rate (75.34%) compared to the control group (73.06%) after the inclusion of 0.9% NaCl solution whereas the vinegar-treated sample was reported as having decreased moisture content (71.48%) which matches with the findings of Sengun et al., (2020) where 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. Offer and Knight, (1988) stated that water-holding capacity, or the ability of meat to retain all or a portion of its water, is among the most crucial elements trait of meat quality. Consequently, weight loss has a financial cost to meat manufacturers and retailers (Watanabe et al., 2018; Verbeke et al., 2005; Ngapo et al., 2007). Vinegar-treated samples displayed a higher percentage (28.45%) of dry matter content (DM) compared to the samples treated with fresh water (control group) whereas DM content lowered with the introduction of NaCl (24.53%). In addition, increasing storage time showed a decreased rate of dry matter content which is analogous to the findings of both Islam et al., (2012) and Konieczny et al., (2007). However, the DM content of beef preservation was highly significant ($p<0.001$) among the treatments. Weight loss has a financial cost to meat manufacturers and retailers.

Ether extract

Samples treated with both vinegar and 0.9% NaCl solutions showed decreasing percentages in Ether extract (EE) content compared to the control group (10.05%) and among them, the lowest value was found with the treatment of 0.9% NaCl solution (6.39%). These findings showed a resemblance with the findings of Islam et al., (2012), 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. The EE content of beef preservation was highly significant ($p<0.001$) among the treatments.

Ash content

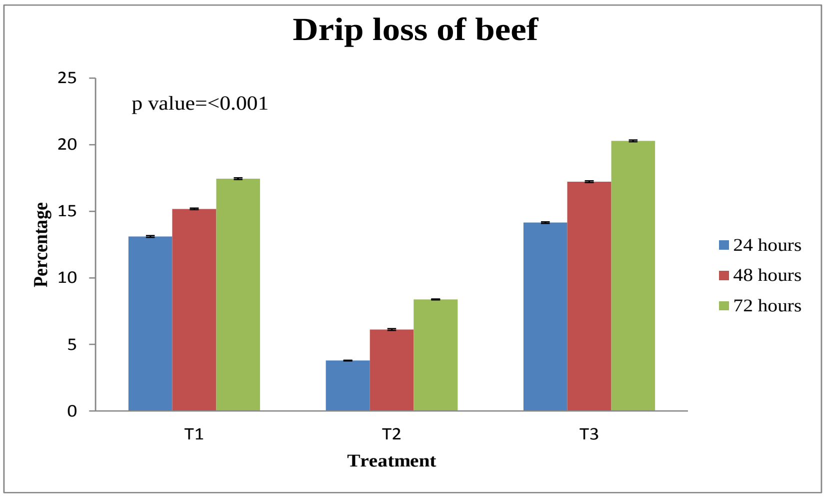
In the comparison of the control group (8.27%) ash content showed a significant increase with the incorporation of vinegar (12.23%) which dramatically reduced to 6.23% treated with NaCl. These findings state that salt incorporation in beef is associated with decreasing ash content corresponding to the findings of Ogunmola et al., (2013) which reported that due to the salt's penetration into the meat and absorption of moisture from the tissue, the ash content was noticeably lower in brine-cured beef. Furthermore, increased storage time also showed decreasing ash value which depicted similar trends found in Islam et al., (2012). There was a highly significant difference ($p<0.001$) in the ash content among the treatments.

Crude protein

Crude protein (CP) content of preserved beef showed a lowered amount when treated with NaCl (15.32%) which suggests that the loss of CP was most likely correlated to the inclusion of NaCl but vinegar treated sample showed an increased amount (22.29%) compared to the control. A similar trend has been found in Sarker et al., (2021) where crude protein content increased due to the incorporation of vinegar. The CP content of beef preservation was highly significant ($p<0.001$) among the treatments.

Drip loss

By analyzing the drip loss after 24 hours, 48 hours, and 72 hours it has been evident from Figure 1 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 exhibited a resemblance with Gersdorff et al., (2021) where acid treatment caused a reduction in drip loss for meat samples. As opposed 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 (20.29%). This finding also displayed a similarity with Gersdorff et al., (2021) 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. The retail fresh meat market is greatly impacted by the way drip loss changes over display time (Otto et al., 2006). Andersen, (2000) asserts that although appearance is still one of major the factors taken into account by customers when choosing goods, there is no direct connection with food quality. The main sensory factors are color, marbling, and drip loss. However, according to certain studies, meat with drip loss is disliked by consumers all over the world (Verbeke et al., 2005; Ngapo et al., 2007). Weight loss and lower yield from drip loss during product manufacture, transportation, and storage may cause financial losses (Mu et al., 2017)



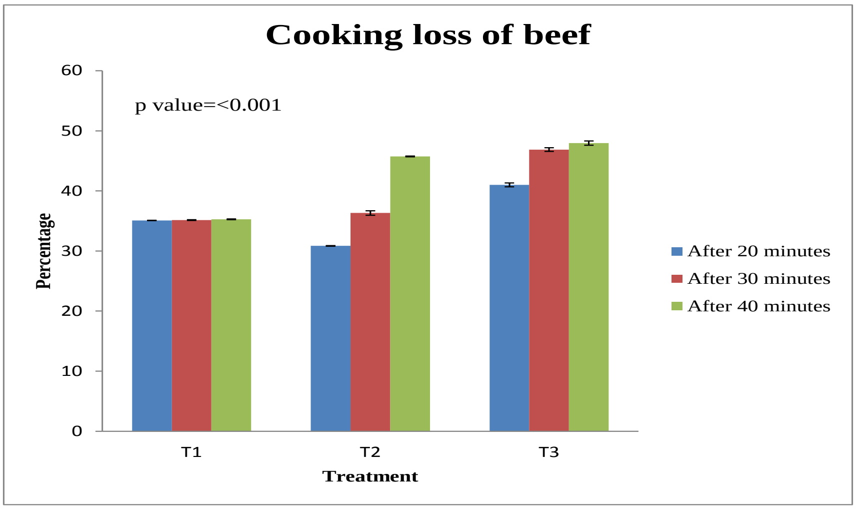
*T_1 (fresh water); T_2 (vinegar); T_3 (0.9% Nacl solution);NS= Non significant,***=$p<0.001$, **=$p<0.01$; *=$p<0.05$*

Figure 1. Drip Loss of beef meat after 24, 48 and 72 hours of preservation.

Cooking loss

The cooking loss of the samples was analyzed after 20 minutes, 30 minutes, and 40 minutes. After 20 minutes cooking loss displayed a declining rate in vinegar-treated samples whereas NaCl-treated samples showed an upward rate of cooking loss (41.02%). 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 Sarker et al., (2021) where the control group experienced the highest cooking loss (no vinegar added) and Vaudagna et al., (2008) where reduction of cooking loss was obtained by the incorporation of both salts alone or in combination. The cooking loss of beef preservation was highly significant ($p<0.001$) in the treatments. Barbanti and Pasquini, (2005) remarked that cooking duration had a strong association with cooking loss compared to cooking temperature. In beef, it has been shown that juiciness and cooking loss are negatively correlated, suggesting that a high cooking loss results in a low juiciness (Aaslyng et al., 2003; Toscas et al., 1999). According to

Garmyn, (2020) the three aspects of cooked beef palatability—tenderness, juiciness, and flavor—are associated with customer satisfaction.

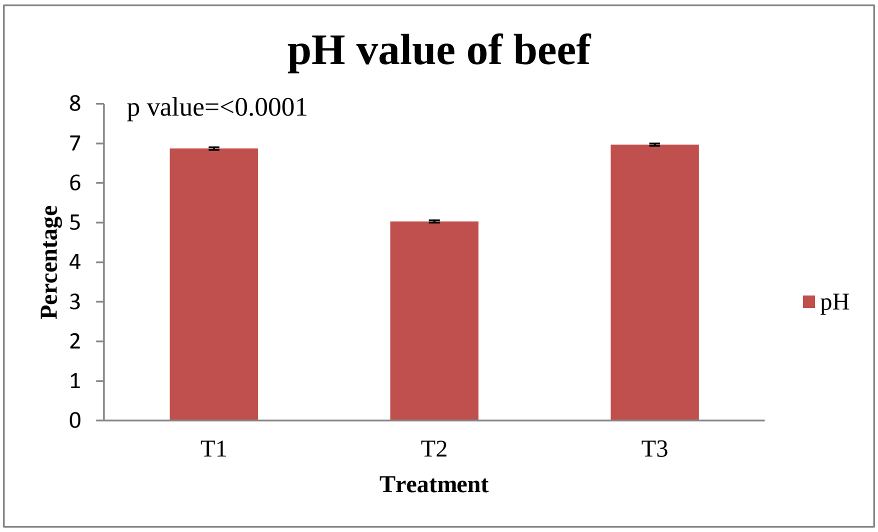


*T_1 (fresh water); T_2 (vinegar); T_3 (0.9% Nacl solution); NS= Non significant,***=p<0.001, **=p<0.01; *=p<0.05*

Figure 2. Cooking Loss of beef meat after 20, 30 and 40 minutes.

pH

Samples treated with 0.9%NaCl solution showed the highest pH value (6.97%) which showed similarity to the findings of Aktas (2003) where NaCl-marinated beef exhibited pH values that were higher in comparison to the control group. By reducing the connections between the tails, NaCl depolymerizes the thick filament shafts, likely promoting the exposure of previously hidden charged and/or hydrophilic groups. The samples that had been treated with vinegar had the lowest pH in our investigation (5.03%) which is consistent with the findings of Sarker et al., (2021) where the beef samples treated with vinegar displayed a lower pH value. According to Jones et al., (2019), the inclusion of acid causes denaturation of the meat surface hence vinegar addition lessens the pH of the meat. In the present study, there was a highly significant difference ($p<0.0001$) in the pH of beef preserved with vinegar and salt among the treatments. However, it was also evident that the pH value dramatically dropped throughout 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.

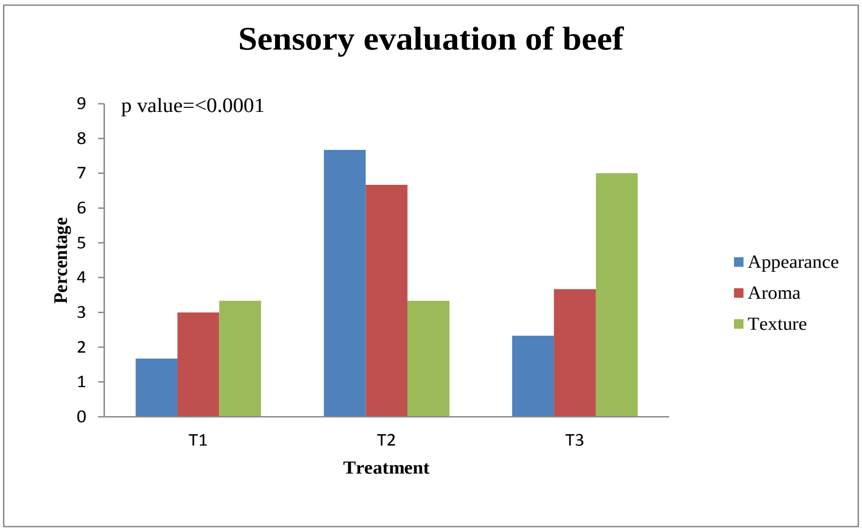


*T_1 (fresh water); T_2 (vinegar); T_3 (0.9% Nacl solution); NS= Non significant,***=p<0.001, **=p<0.01; *=p<0.05*

Figure 3. pH value of beef.

Sensory evaluation

The findings of the taste panel's assessment of the beef's appearance, aroma, and texture after five hours of preservation are reported in Figure 3. In 5 hours of preserved beef, sensorial characteristics values were found at 1.67, 7.67, and 2.33(appearance); 3.00, 6.67, and 3.67(aroma); 3.33, 3.33, and 7.00(texture); in T_1, T_2, and T_3, respectively. Beef samples treated with NaCl solution were chosen as the most desirable appearance. The strength of the meat flavor diminished with the rising inclusion of vinegar. The incorporation of salt increased the aroma and appearance of beef. Sensory scores also indicated that T_3 was more acceptable than T_2. However, there was little significant change of texture to all the treatments.



T_1 (fresh water); T_2 (vinegar); T_3 (0.9% Nacl solution)

Figure 4. Sensory evaluation of beef.

Color analysis

After five hours of preservation, beef samples treated with vinegar exhibited the most desirable *L** (46.17%) and *b** (2.53%), which concurs with the outcome of Sarker et al., (2021), who also found that vinegar-treated samples showed the superior color of the beef samples. Introducing salt and fresh water makes samples appear more attractive in redness. However, there was little significant change in color in respect of all the treatments.

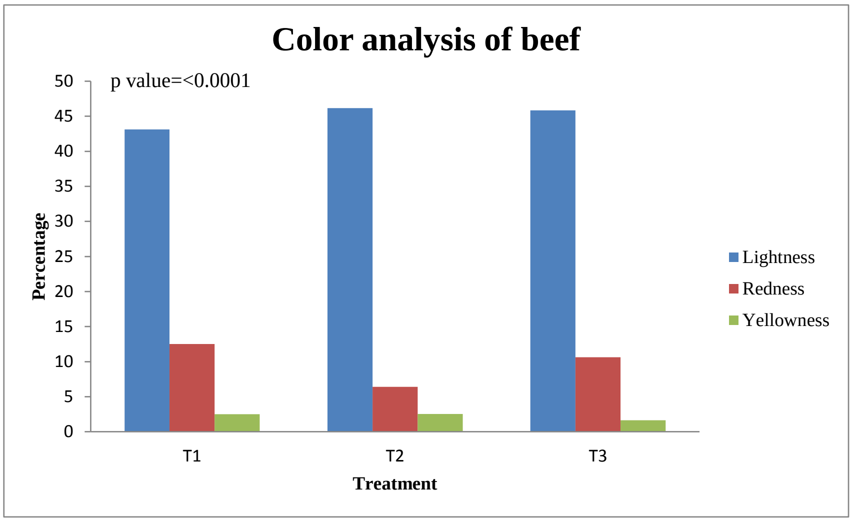


Figure 5. Color analysis of beef meat.

T_1 (fresh water); T_2 (vinegar); T_3 (0.9% Nacl solution).

Table 2. Pearson correlation coefficients among selected color and sensory properties of beef

Parameters	1	2	3	4	5	6
1.*L**						
2. *a**	0.9385^{NS}					
3. *b**	0.1088^{NS}	0.0094^{**}				
4. *c**	0.0002^{***}	0.3046^{NS}	0.5341^{NS}			
5. *h**	0.0296^{*}	0.0586^{NS}	$<.0001^{***}$	0.2502^{NS}		
6. *t**	0.0525^{NS}	0.0355^{*}	$<.0001^{***}$	0.3462^{NS}	$<.0001^{***}$	

L*=Lightness, a*= Redness, b*= Yellowness, c*= Appearance, h*= Aroma, t*=Texture NS= Non significant, ***=p<0.001, **=p<0.01; *=p<0.05.

Correlation matrix of selected color and sensory properties of beef

The results of Pearson's correlation coefficients correlation analysis among selected color and sensory attributes of beef are displayed in Table 2. A significant ($p<0.05$) association was found between *L* and *h* (r=0.0296); and *a* and *t* (r=0.0355). There were also highly significant ($p<0.001$) associations between *L* and *c* (r=0.0002); *b* and *h* (r=<0.0001); *b* and *t* (r=<0.0001); *h* and *t* (r=<0.0001); and *a* and *b* ($p<0.01$, r=0.0094). The correlations between other properties were found non-significant ($p>0.05$).

Conclusion

This study investigated the effects of administering a diverse dosage of vinegar, and 0.9% NaCl solution on the nutritional and physical properties, sensory quality, and color of raw beef. Following analysis of the data, it was determined that vinegar, which preserved the color and sensory qualities of raw beef while having a positive effect on the physical and nutritional properties (pH, cooking yield, drip loss, and cooking loss), is a more conventional disinfectant that meat producers and retailers should use during the processing of beef. Additionally, adding it might allow a decrease in contamination and an increase in shelf life without affecting the meat's sensory qualities. Future research could be directed toward meat preservation, improving shelf life, and lowering the microbial load.

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