KUFA JOURNAL FOR VETERINARY MEDICAL SCIENCES

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Evaluation of the Effect of Trisodium Phosphate on Physical and Chemical Characterizations in Local Beef

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ABSTRACT

A total of 140 beef samples were used in this study to investigate the effects of trisodium phosphate (TSP) on beef quality at ambient temperature and during refrigerated storage at 4 °C. The TSP is commonly applied in the meat industry to enhance water holding capacity, improve texture, and increase overall quality by interacting with meat proteins and preventing lipid oxidation. Different concentrations of TSP were applied to evaluate physicochemical properties such as pH and thiobarbituric acid reactive substances (TBARS). Results showed that treatment with 10% TSP for 5 minutes was the most effective compared to other concentrations. The use of TSP increased pH, which improved the water holding capacity of meat and enhanced both quality and texture. The highest pH value was observed at ambient temperature (9.23) and was statistically significant compared to the control (6.13). A significant reduction in TBARS was also recorded, with the lowest oxidation value (0.25) observed under refrigeration after 48 hours compared to the control (0.45). These findings confirm that TSP is an effective treatment to extend beef shelf life without altering its chemical composition.

ARTICLE INFO
Article history:
Received: 2 June 2025
Accepted: 9 October 2025
Published: 31 December 2025
DOI: https://doi.org/10.36326/kjvs/2025/v16i119203
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P- ISSN: 2077-9798
E- ISSN: 2959-8478

KEYWORD: Beef, TSP, PH, TBARS, Ambient temperature, and Refrigeration storage.

INTRODUCTION

Beef sold at retail markets can be contaminated with microorganisms which are of public health significance and impact on the shelf-life of meat [1]. A common habit among most of the population in many Middle Eastern countries is dependence on meat as the primary source of food [2,3]. However, they are also classified as highly perishable commodities and susceptible to many spoilage agents and

pathogens [4]. Under hygienic slaughter conditions, a healthy animal yields meat generally considered sterile before skinning [5]. However, during the skinning stage, the carcass may become exposed to microbial contamination from various sources, such as personal handling and the processing environment [6]. Many chemicals protect meat from spoilage and extend its shelf life. Studies on the chemical disinfection of meat carcasses have been conducted worldwide over the past 30 years. Numerous chemical agents have been utilized to eliminate pathogens from the surface of meat [5].

Trisodium phosphate (TSP) is one such alkaline substance. It can efficiently dissolve proteins and has an antibacterial effect due to its ability to bind to the cell wall, reducing the fat layer on the surface of meat and preserving meat quality, thereby ensuring consumer safety [7]. Furthermore, the United States Food and Drug Administration (FDA) has recognized TSP as safe, which permits its use at a concentration of 8–12%. Additionally, it is classified as an acceptable food additive in China [8,9]. Therefore, TSP plays a crucial role in meat and meat production due to several functional properties; it helps increase the pH of meat, enhances water-holding capacity (WHC), and opens up the muscle protein structure, which leads to improved yield and stabilization of meat emulsions. Additionally, TSP reduces cooking loss during cooking, enhances texture and sensory attributes, and extends the shelf life of meat products [10, 11].

Due to the health and economic problems associated with meat spoilage, which impact meat quality, this study was designed to determine the ability of TSP to maintain meat quality and stability at ambient temperature and during refrigerated storage.

MATERIAL AND METHODS:

Preparation of Meat and Trisodium Phosphate for Treatment

A total of 140 fresh meat samples were randomly collected from local butcher shops in Baghdad. Obtained as half-kilogram portions, were divided into three groups representing exposure at ambient temperature and refrigerated storage for 24 and 48 hours. The meat was weighed into cubes of 25 grams. The meat cubes were packed in sealed sterile polyethylene bags under the same shop conditions to control moisture loss during the various steps from collection and transportation until they were transferred to the Graduate Laboratory of Milk and Meat/Department of Veterinary Public Health/University of Baghdad to evaluate the physical and chemical tests before and after exposure to TSP treatment (Thomas baker/ India). Different volumes of TSP solution as 6, 8 and 10% (w/v) were prepared by dissolving 6, 8 and 10 grams of TSP powder in 100 ml of the sterile distilled water in volumetric flasks and stirred for 5-10 minutes at room temperature (22±1 °C) until it completely dissolved.

For evaluation of the effect of TSP on the physicochemical properties of meat at different concentrations (6%, 8%, 10%), the experiment was repeated in triplicate at (ambient and 4°C). The meat cubes were kept in sterile bags and immersed three different times for 5, 10, and 20 minutes. The bags used for meat samples were immersed in TSP immediately after refrigerator storage (4°C) for 24 and 48 h. After the immersion treatment, the meat cubes were aseptically removed for physicochemical analysis. Untreated meat samples were used as a control (time zero).

Physicochemical analysis:

The physical and chemical properties

of local fresh samples at ambient and refrigeration temperatures and the pH and thiobarbituric acid reactive substances (TBARS) levels were evaluated before and after exposure to the TSP process [12].

pH Analysis:

The pH values of both control and TSP-treated meat samples were determined. For this analysis, 10 grams of each meat sample were homogenized with 50 mL of distilled water (DW) using a laboratory blender for 1 to 3 minutes, and the homogenate was then filtered. The pH was determined using a digital pH meter, and the solution was standardized at both pH 4 and pH 7. Triplicate measurements were used for each meat sample [13].

Thiobarbituric Acid Reactive Substances Content (TBARS):

Fat oxidation in beef was analyzed before and after treatment with TSP. Fat oxidation was determined by measuring thiobarbituric acid-reactive substances (TBARS); the experiment was performed in triplicate, as described in [14]. A 10 mL volume of 20% trichloroacetic acid (TCA) solution was added to a five-gram beef sample. The mixture was homogenized using a vortex mixer for 1 min, centrifuged at 2800 × g for 15 min. From the resulting supernatant, 5 mL of 0.02 M thiobarbituric acid (TBA) solution was mixed with 5 mL of 20% TC(and then combined with 5 mL of the TBA control. All test tubes containing the solutions were boiled in a water bath at 100°C for 20 minutes, followed by a 10-minute cooling period. The absorbance of the test solution was measured spectrophotometrically at a wavelength of 532 nm. The TBARS values were calculated using the formula.

TBARS = (A532 + 0.002) ×2.587

TBARS was expressed as milligrams of malondialdehyde (MDA)/kilogram of meat.

Statistical analysis:

Data were analyzed using SAS (Statistical Analysis System—version 9.1). Results are expressed as mean ± standard error. A two-way ANOVA was applied, followed by the least significant differences (LSD) test to assess significant differences among means. ($P < 0.05$) is considered statistically significant [15].

RESULTS

The effect of TSP on the beef meat pH values at ambient and refrigeration storage.

The pH value significantly impacts color, storage time, and texture in meat and its products; thus, it is one of the most essential attributes in meat production [16]. Food-grade phosphates are beneficial for decontaminating food while processing meat and meat products. The results showed that trisodium phosphate used in this study has different effects on the pH level. Significant ($p < 0.05$) changes in pH values of samples treated with 10% TSP for 5 min Table (1), the average pH values of beef samples treated with 10% TSP at ambient temperature for 5 minutes was 9.23 compared to the control untreated samples 6.13, while after storage samples at 4°C for 24 and 48 h and treated with TSP with the same concentration and contact time, the pH values was 8.63 and 7.77 respectively as show in Table (2, 3). These results indicate that TSP can raise the beef pH at all concentrations used in the current study compared to control, untreated samples. However, the optimal concentration and contact time of 10% for 5 minutes was the best under all conditions.

Table 1. The mean values of beef meat pH after subjecting to the TSP treatment at ambient temperature.

Concentrations/ TSP	pH values (Means±SE)			
	Time intervals/ minutes			
	*Time zero	5	10	20
6%	C6.13±0.12a	A9.00±0.05b	AB8.86±0.02a	B8.73±0.03a
8%	B6.13±0.12a	A9.00±0.06b	A8.93±0.03a	A8.83±0.06a
10%	C6.13±0.12a	A9.23±0.06a	B8.96±0.03a	B8.93±0.03a
LSD	0.21			

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)
*Time zero: Untreated samples were used as the control.
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Table 2. The mean values of beef meat pH after subjecting to the refrigeration storage (24 hrs) and TSP treatment.

Concentrations/ TSP	pH values (Means±SE)			
	Time intervals/ minutes			
	Time zero	5	10	20
6%	C5.96±0.12a	A8.26±0.12b	AB8.13±0.03b	B7.93±0.08b
8%	C5.96±0.12a	A8.40±0.11ab	AB8.23±0.06ab	B8.13±0.08ab
10%	C5.96±0.12a	A8.63±0.08a	AB8.43±0.08a	B8.33±0.08a
LSD	0.27			

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)

Table 3. The mean values of beef meat pH after subjecting to the refrigeration storage (48 hrs) and TSP treatment.

Concentration/ TSP	pH values (Means±SE)			
	Time intervals/ minutes			
	Time zero	5	10	20
6%	B6.00±0.05a	A7.43±0.08b	A7.27±0.03a	A7.17±0.14a
8%	C6.00±0.05a	A7.50±0.17ab	AB7.37±0.12a	B7.20±0.10a
10%	C6.00±0.05a	A7.77±0.06a	B7.43±0.03a	BC7.27±0.08a
LSD	0.29			

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)

The Effect of TSP treatments on thiobarbituric acid reactive substances (TBARS) of beef meat samples at ambient and refrigeration storage

Table (4) shows the values of TBARS in beef samples treated with (6%, 8%, and 10%) of TSP solution at ambient temperature for 5, 10, and 20 minutes, samples stored at 4°C for 5, 10, and 20 minutes after 24- and 48-hours of refrigerated storage. Tables (5, 6). There were statistically significant differences (P > 0.05) in the average TBARS values at the 10% concentration for 5 minutes, compared to the control group at ambient temperature and samples stored at 4°C for 24 and 48 hours, respectively. TSP could raise the pH and reduce TBARS values compared to the control samples. TSP positively reduces lipid oxidation (measured by TBARS values) in meat over extended storage periods. No significant differences were observed between the TSP and control groups in the first few days of storage.

Table 4. The mean values of beef meat thiobarbituric acid reactive substances (TBARS) (mg of MDA/kg) after subjecting to the TSP treatment at ambient temperature.

	TBARS values (Means±SE)			
Concentrations/ TSP	**Time intervals/ minutes**			
	Time zero	**5**	**10**	**20**
6%	B0.40±0.01a	B0.37±0.01a	B0.39±0.01a	A0.46±0.00a
8%	A0.40±0.01a	B0.35±0.01a	AB0.37±0.00ab	AB0.38±0.00b
10%	A0.40±0.01a	C0.31±0.01b	B0.35±0.01b	AB0.37±0.01b
LSD	0.04			

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).

Table 5. The mean values of beef meat TBARS at refrigeration storage for 24 hrs and TSP treatment.

	TBARS values (Means±SE)			
Concentration/ TSP	**Time intervals/ minutes**			
	Time zero	**5**	**10**	**20**
6%	A0.42±0.01a	B0.34±0.03a	B0.37±0.01a	AB0.40±0.00a
8%	A0.42±0.01a	C0.33±0.02a	BC0.35±0.01a	B0.37±0.00ab
10%	A0.42±0.01a	C0.29±0.02b	B0.34±0.01a	B0.35±0.01b
LSD	0.04			

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).

Table 6. The mean values of beef meat TBARS at refrigeration storage for 48 hrs and TSP treatment.

	TBARS values (Means±SE)			
Concentrations/ TSP	**Time intervals/ minutes**			
	Time zero	**5**	**10**	**20**
6%	A0.45±0.03a	B0.32±0.01a	B0.33±0.01a	B0.37±0.02a
8%	A0.45±0.03a	B0.30±0.02a	B0.30±0.01ab	B0.34±0.02ab
10%	A0.45±0.03a	C0.25±0.01b	B.26±0.01b	B0.31±0.02b
LSD	0.05			

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).

DISCUSSIONS

Food phosphates are essential food additives related to the processing of meat and meat products, helping to improve the food texture and sensory properties, such as tenderness, juiciness, and extending shelf life [10]. The alkaline nature of TSP can affect the pH of meat, causing a significant increase in pH [17]. Studies have shown that maintaining the pH above the isoelectric point of meat muscle proteins (5.0–5.3) increases the water-holding capacity (WHC) of meat and leads to reduced meat moisture loss, improved quality and texture [18]. Of all the concentrations and exposure times used in the study, the 10% TSP treatment for 5 minutes at ambient temperature showed the most pronounced effect on raising the pH value. This increase may be attributed to the strongly alkaline nature of trisodium phosphate, which directly affects the protein environment in meat tissue, increasing protein spacing and improving water-holding capacity (WHC), consistent with previous studies [19]. The high concentration and short exposure time at ambient temperature provided a suitable environment for inducing chemical changes without causing damage or undesirable changes in physical properties. Therefore, the 10% TSP treatment for 5 minutes at ambient temperature can be considered one of the best treatments used in this study to raise pH and improve meat quality.

After meat samples were stored at refrigerated temperatures and treated with 10% trisodium phosphate (TSP) for 5 minutes, it was observed that pH values remained significantly higher than those of untreated control samples, even after 24 and 48 hours of storage. Despite this relative stability, a gradual decrease in pH was observed after 24 hours, reaching pH 7 after 48 hours of short-term storage. These results indicate that TSP treatment directly affects the chemical properties of meat, notably by maintaining the alkalinity of the medium for a more extended period. Furthermore, refrigerated storage indirectly contributes to pH modification by slowing down chemical reactions. Monitoring pH is a vital tool for assessing the quality and freshness of fresh and processed meat. [5]. Previous research suggests that storage at 4°C helped maintain stable pH values compared to storage at 10°C, with samples stored at this temperature experiencing a less rapid decline in pH over time. The study also demonstrated that higher pH values (>6.3), especially after the use of trisodium phosphate (TSP), contributed to improved meat tenderness and quality during refrigerated storage [20].

Oxidation processes degrade meat quality, adversely affecting its flavor, texture, and color. Additionally, they promote the formation of toxic compounds, diminish neutral value, and shorten shelf life. Antioxidants were incorporated into meat

products to mitigate these effects and delay, inhibit, or prevent oxidative reactions. [21, 22].

Treating meat with 10% TSP significantly reduced TBARS values after 5 min. of application, demonstrating that TSP can positively influence inhibiting lipid oxidation in beef. This rapid effect highlights the role of TSP in improving the oxidative stability of meat products even during short processing periods [23, 24].

Fat oxidation was not a significant problem in any of the treatments, but 10% for 5 minutes was the best, especially when refrigerated, compared to control samples. Compared to control samples, TSP showed better lipid stability, especially when refrigerated at 4°C. This is consistent with other research, where one study showed that in later days (especially day 7), TSP played an effective role in maintaining lipid stability (TBARS) [12].

The Food Safety and Inspection Service (FSIS) recommended that fresh meat, such as poultry and beef, be consumed within two days and 3 to 5 days, respectively, during storage at refrigeration temperature [5]. When trisodium phosphate is applied to meat and its products, it can improve or maintain the same sensory properties, instrumental color, sensory odor, lipid oxidation, sensory taste, shear characteristics, and cooking characteristics. Therefore, these antimicrobial treatments can be used in the industry as a measure to improve safety without negatively affecting the fresh product [12].

CONCLUSIONS

Applying TSP as an effective and safe method to improve the quality of fresh local beef stored at room temperature (4°C) without affecting the local meat's physical and chemical quality.

ACKNOWLEDGEMENTS

Thanks to the head of the high-graduate milk and meat Laboratory at the University of Baghdad for providing all the assistance needed to complete the current study.

NOVELTY STATEMENT

The importance of this research lies in highlighting the treatment of local beef with the chemical substance trisodium phosphate (TSP) and its effect on improving the physical and chemical properties of this meat sold in Iraqi markets. This study is considered an effective and safe method for preserving the quality of this type of food, which the Iraqi people widely consume. The very few studies in this field indicate the effectiveness of using TSP in enhancing meat quality and extending its shelf life without negatively affecting its nutritional or chemical health.

AUTHOR'S CONTRIBUTIONS

Ibraheem EIBRHIM took responsibility for data collection and TSP treatment analysis, while the research design was prepared under the supervision of advisor Dr Zina Saab Khudhir. Both authors approved the final version of the submitted manuscript to this journal.

CONFLICT OF INTEREST

No potential conflicts of interest relevant to this article are reported.

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