Research Article

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Evaluation Of Shelf Life of Restructured Turkey and Chicken Meat Slices Under Frozen (18±1°C) Storage

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ABSTRACT

The study was aimed to evaluate the shelf life of restructured turkey meat slices with and without polyphosphate and chicken meat slices containing polyphosphate were evaluated at 30 days interval up to 90 days. The slices were packed in low density polyethylene (LDPE) bags, stored at -18±1oC and evaluated at 30 days interval for physicochemical, microbiological and sensory attributes. The pH of turkey meat slices with polyphosphates was found to be higher than turkey meat slices without polyphosphate. A steady and significant increase in the TBARS value was noticed in restructured turkey meat slices without polyphosphate during the entire storage period of 90 days. In all the three products there was an increase in TBARS value till 60th day and then a decrease was found on the 90th day. No significant increases in microbial counts were observed and were within acceptable limits (7 log10 cfu/gm) for a cooked meat product. Coliforms and Psychrotrophs were also not detected throughout the storage period of 90 days. Yeast and mould growth was detected only up to 60 days and no growth was observed on 90th day. Appearance of the products showed a gradual decrease during the storage period. There was a significant decrease in flavour from 30th day onward in case of restructured turkey meat slices without polyphosphate and from 60th day onward in restructured turkey and chicken meat slices with polyphosphate. There was a significant decrease in juiciness and texture of restructured turkey meat slices without polyphosphate. The overall palatability showed a continuous decrease in turkey meat slices with and without polyphosphate but it was very slow in chicken meat slices with polyphosphate during frozen storage.

Keywords: Restructured slices; polyphosphate; frozen storage; chicken meat; turkey meat and storage stability

INTRODUCTION

Turkey meat is becoming increasingly popular in the poultry market because it is affordable, versatile, nutritious, and has good sensory qualities such as tenderness, juiciness, and flavor. It is also valued for its healthy lipid profile, moderate cholesterol, high-quality protein, and rich micronutrient content, including selenium, niacin, and vitamin B6 (García Solaesa et al. 2024). The demand in the turkey meat and its processed products has only increased in the past years due to the changing consumer preferences toward high-protein, low-fat, and functional foods (FAO, 2025; Yue et al. 2024).

The processed poultry meat products are extremely prone to quality degradation during storage, which is mainly related to lipid oxidation and related biochemical alterations. Recent research has also emphasized the fact that, despite frozen temperatures, oxidative alterations still take place which influence sensory qualities and the overall acceptability of the product (Falowo et al. 2023; Jung et al. 2025). Besides lipid oxidation, protein oxidation and structural changes are all part of the processes that worsen the texture and water-holding capacity during storage (Amaral et al. 2024). To counter the effects of such quality variations, there are several functional ingredients that are added to processed meat systems. Among them, the phosphates have long been an important ingredient because of their capacity to increase water-holding capacity, better cooking yield, stabilize emulsions, and affect texture. Phosphates can be used to enhance the ionic strength and PH of the meat system and hence protein solubilization and water binding into the muscle matrix. These functional properties are further improved when interacting with sodium chloride in a synergistic way (Xiong, 2023).

The restructured meat products have become a significant category as they allow the use of small meat scraps, trimmings, and other less desirable cuts to be used in homogenous economically viable and acceptable products to the consumer. Sharma et al. (2014) reported that extended restructured mutton chops could be prepared by massaging meat chunks for 10 minutes, with the product extended using 5% pea hull flour and 5% boiled, mashed potato. Effect of natural preservatives like powders of red grapes, gooseberry and tomato on the quality and shelf life of restructured chicken block was evaluated under the refrigerated (7±1°C) storage (Najeeb et al. 2015). Gupta et al. (2015) studied the effect of incorporation of potato (Solanum tuberosum) on the physico chemical and sensory quality of restructured spent hen meat blocks and found that level of 12% was found optimum. Restructured fish nuggets were made from low-value cuts of 'Wallago attu' (Boal), by combining soy protein isolate and study concludes that 7.5% soy protein isolate was found to be best for making cost effective fish nuggets (Biswas et al. 2016). Restructured buffalo meat fillets formulation was optimized by replacing lean meat with different levels of hydrated barley flour. The study concludes that 12 percent hydrated barley flour was found optimum (Ahmad et al. 2022). Basha et al. (2023) reported that chunk size of 7.5×10×5 cm for cold-set restructured beef made with microbial transglutaminase was found to be most acceptable.

Although significant progress has been made in the field of poultry meat processing, the scientific literature specifically addressing the processing characteristics and storage stability of restructured turkey meat products remains limited. In particular, comparative studies evaluating the role of functional additives such as sodium tripolyphosphate in turkey versus chicken restructured products under frozen storage conditions. Therefore, the present investigation was undertaken to evaluate the processing quality and storage stability of restructured turkey meat slices prepared with and without sodium tripolyphosphate, and to compare them with restructured chicken meat slices containing sodium tripolyphosphate during frozen storage (-18±1°C).

MATERIALS AND METHODS

Broiler spent hen and turkey meat

Broiler spent hens and dressed carcasses of female Black Turkey and Beltsville Small White Turkey were procured from the Central Avian Research Institute (CARI), Izatnagar. Immediately after procurement, carcasses were subjected to manual hot deboning under hygienic conditions. Carcass components were recorded, and visible fat, fascia, and connective tissues were carefully trimmed to ensure uniformity of raw material.

Processing of restructured turkey and chicken meat blocks

Frozen meat samples were thawed under refrigerated conditions (4±1°C) for 12–16 hours to minimize drip loss and protein denaturation. The meat was then cut into approximately 3 cm cubes and dark and white meat were mixed in their natural carcass proportion (46.8% dark meat and 53.2% white meat). The formulation included sodium nitrite (150 ppm), common salt (1.8%), sodium tripolyphosphate (0.4%, except in control), and sugar (0.3%). The ingredients were mixed using a paddle mixer (Electrolux) for 2 minutes to facilitate extraction of salt-soluble proteins. Ice flakes (7.2%) were added to maintain low batter temperature and enhance protein functionality, followed by further mixing for 2 minutes. Condiments (2.4%) and whole egg liquid (3.5%) were incorporated and mixed for 3 minutes until a tacky exudate indicative of protein extraction and binding was obtained. Refined wheat flour maida (2.4%) was then added as a binder and mixed for an additional 3 minutes. Approximately 3 kg of batter was prepared for each formulation.

The batter was filled into aluminium moulds (16.5 × 8 × 6 cm) and subjected to steam cooking for 45 minutes until the internal core temperature reached 92±2°C. Post-cooking, exudate was drained and blocks were cooled and conditioned at 4±1°C overnight. The chilled blocks were sliced into uniform slices (5 mm thickness) using a mechanical slicer (Electrolux OMAS). Approximately 250 g slices were packed in LDPE bags (200 gauge) and stored under refrigerated (4±1°C) or frozen (-18±1°C) conditions for further evaluation.

Analytical Procedures

Physico-chemical Analysis

The pH of samples was measured using a calibrated digital pH meter (Elico, Model LI-127, India) after homogenizing 10 g of sample in distilled water. Lipid oxidation was estimated by determining the thiobarbituric acid reactive substances (TBARS) value following the distillation method of Tarladgis et al. (1960), expressed as mg malonaldehyde/kg of sample.

Microbiological Evaluation

Microbiological quality of restructured meat slices was evaluated as per ICMSF (1996) guidelines with modifications based on recent standard practices. Samples (10 g) were aseptically homogenized with 90 ml of sterile 0.1% peptone water to obtain a 10^{-1} dilution. Serial dilutions were prepared under aseptic conditions in a laminar airflow cabinet pre-sterilized by UV irradiation. Total viable (mesophilic) counts were determined using Plate Count Agar (HiMedia M091) and incubated at 37±1°C for 48 hours. Plates showing 30–300 colonies were counted and expressed as $\log_{10}$ cfu/g. Yeast and mould counts were determined using Potato Dextrose Agar (HiMedia M096), incubated at 25±1°C for 5 days. Colonies of different morphologies were counted and expressed as $\log_{10}$ cfu/g.

Sensory Evaluation

Sensory evaluation was conducted using an 8-point descriptive scale (Keeton, 1983), where 8 = excellent and 1 = extremely poor. A trained panel of seven members comprising scientists and postgraduate students evaluated the samples. Samples were tempered to serving temperature (40–45°C) using a microwave oven prior to evaluation. Attributes including appearance, flavour, juiciness, texture, binding, and overall acceptability were assessed using a standardized score sheet. Evaluations were conducted under controlled conditions, and panelists were provided with potable water for palate cleansing between samples.

Statistical Analysis

The experiment was done thrice and data were analyzed using a randomized block design. Statistical analysis was performed using SPSS software. Data were subjected to one-way and two-way analysis of variance (ANOVA) to determine the effects of treatments and storage periods. Significant differences between means were evaluated using least significant difference (LSD) and Duncan's multiple range test (DMRT) at a 5% level of significance ($P < 0.05$).

RESULTS AND DISCUSSION

Physico-chemical Characteristics

pH

The pH values of all the restructured meat products did not exhibit any significant variation (P>0.05) throughout the 90 days of frozen storage (Table 1). This indicates that the products maintained physicochemical stability under frozen conditions. Among treatments, restructured turkey meat slices containing polyphosphate exhibited slightly higher pH values compared to the control (without polyphosphate), whereas chicken meat slices with polyphosphate showed pH values comparable to control turkey slices. The increase in pH in phosphate-treated products may be attributed to the alkaline nature of phosphates, which enhance ionic strength and promote protein solubilization, thereby increasing water-holding capacity and buffering effect. Similar observations have been reported in modern meat processing literature, where phosphates are recognized for their role in stabilizing pH and improving functionality of meat proteins (Xiong, 2023; Kim et al. 2025). In agreement with our findings, Najeeb et al (2015) reported similar pH values in restructured chicken products The absence of significant pH variation during frozen storage aligns with recent findings that freezing primarily affects structural and oxidative properties rather than causing drastic pH changes in cooked meat products (Zhu et al. 2025).

Table 1: Effect of frozen (-18±1°C) storage on the physicochemical properties of restructured meat products

Treatment	0 Days	30 Days	60 Days	90 Days
pH				
Turkey without PP (control)	6.26±0.04	6.30±0.06	6.33±0.01	6.35±0.01
Turkey with PP	6.34±0.03	6.38±0.06	6.39±0.01	6.40±0.02
Chicken with PP	6.26±0.05	6.26±0.08	6.30±0.02	6.32±0.01
TBARS (mg malonaldehyde/kg sample)				
Turkey without PP (control)	0.18±0.03[illegible]	0.36±0.02[illegible]	0.41±0.01[illegible]	0.37±0.12[illegible][illegible]
Turkey with PP	0.15±0.03	0.28±0.05	0.31±0.04	0.19±0.04[illegible][illegible]
Chicken with PP	0.12±0.02	0.19±0.05	0.29±0.01	0.15±0.04[illegible]
Standard Plate Count ($\log_{10}$ cfu/g)				
Turkey without PP (control)	2.36±0.31	3.14±0.25	3.17±0.32	2.52±0.12
Turkey with PP	2.91±0.18	2.67±0.13	3.14±0.29	2.58±0.03
Chicken with PP	2.43±0.11	2.48±0.10	3.05±0.43	2.47±0.08
Yeast and Mould count ($\log_{10}$ cfu/g)				
Turkey without PP (control)	0.88±0.56	1.37±0.69	0.81±0.51	N.D.
Turkey with PP	0.81±0.51	1.16±0.58	0.23±0.23	N.D.
Chicken with PP	1.29±0.32	1.35±0.67	1.16±0.58	N.D.

n = 9; Means with different superscript (small letters in same row and capital letters in the same column) indicate significant difference (P< 0.05); N.D.-Not detected

TBARS Value

A significant increase (P<0.01) in TBARS values was observed in restructured turkey meat slices without polyphosphate throughout the storage period, indicating progressive lipid oxidation. In contrast, no significant increase (P>0.05) was observed in turkey and chicken meat slices containing polyphosphate, highlighting its antioxidative and stabilizing effects. In all treatments, TBARS values increased up to 60 days followed by a decline at 90 days. This decrease may be attributed to secondary reactions of malondialdehyde (MDA) with proteins, amino acids, and phospholipids, forming non-reactive compounds and thereby reducing measurable TBARS values.

Recent studies strongly support these findings. Lipid oxidation has been identified as a major factor affecting quality deterioration during frozen storage of poultry meat. Jung et al. (2025) reported that lipid-protein oxidation significantly influences flavour, colour, and volatile compounds during frozen storage. Similarly, Amaral et al. (2024) emphasized that TBARS remains a reliable indicator of oxidative stability, though advanced methods such as volatile profiling are increasingly used. The lower TBARS values in phosphate-treated samples may be due to improved water retention and reduced exposure of lipids to pro-oxidants. Modern clean-label research also confirms that phosphate is inevitable and use of its alternatives is challenging due to its multifunctional role in controlling oxidation, texture, and water-holding capacity (Kim et al., 2025).

Microbiological Quality

The microbiological analysis revealed no significant increase (P>0.05) in total plate count (TPC) during the 90-day frozen storage period (Table 1). The microbial counts remained well within acceptable limits (<7 log10 cfu/gm), indicating good hygienic quality and effectiveness of processing and storage conditions (Table 1).

TPC increased up to 60 days and decreased thereafter at 90 days, which may be due to sublethal injury and reduced metabolic activity of microorganisms under prolonged frozen storage. Similar findings have been reported in earlier studies and are supported by modern research indicating that freezing suppresses microbial growth but does not completely eliminate microorganisms (Jha et al. 2026). Coliforms were not detected throughout the study, confirming good hygienic practices and adequate thermal processing. Psychrotrophic bacteria were also absent, likely due to heat treatment during cooking and inability of injured cells to recover under frozen conditions.

Yeast and mould counts were detected only up to 60 days and were absent at 90 days. These findings are consistent with the fact that fungal growth is inhibited at temperatures below -5°C. Contemporary studies also emphasize that frozen storage significantly reduces microbial activity, though contamination control prior to freezing remains critical (Augustyńska-Prejsnar et al. 2024). Thus, microbiological results confirm that restructured meat slices remained safe and stable during frozen storage.

Sensory Attributes

Appearance scores declined gradually during storage in all treatments; however, the decline was significantly higher (P<0.01) in turkey meat slices without polyphosphate at 60 and 90 days. Phosphate-treated turkey and chicken slices maintained better appearance scores. This may be attributed to improved water retention, reduced drip loss, and lower oxidative changes in treated samples. Modern research confirms that frozen storage leads to ice crystal formation and structural damage, which negatively affects visual quality (Leygonie et al. 2012).

Flavour scores decreased significantly (P<0.01) from 30 days onward in control samples and from 60 days onward in phosphate-treated samples. The earlier decline in control samples is likely due to higher lipid oxidation, as supported by elevated TBARS values. Recent studies have established a strong relationship between lipid oxidation and flavour deterioration in poultry meat. Jung et al. (2025) demonstrated that oxidative changes lead to formation of aldehydes and other volatile compounds responsible for off-flavours. Juiciness scores decreased significantly in turkey meat slices (with and without phosphate) from 60 days onward, whereas chicken slices with phosphate-maintained juiciness up to 90 days.

Table 2: Effect of frozen (-18±1°C) storage on the sensory attributes* of restructured meat products

Treatment	0 Days	30 Days	60 Days	90 Days
Appearance				
Turkey without PP (control)	7.19±0.09□	7.05±0.06□	6.30±0.11□□	5.98±0.21□□
Turkey with PP	7.19±0.09	7.17±0.07	6.83±0.10□	6.86±0.08□
Chicken with PP	6.98±0.11	7.10±0.04	6.85±0.09□	6.82±0.09□
Flavour				
Turkey without PP (control)	7.06±0.09□	6.46±0.11□□	5.92±0.16□□	5.67±0.16□□
Turkey with PP	7.04±0.09□	7.19±0.10□□	6.75±0.14□□	6.58±0.11□□
Chicken with PP	6.95±0.11□	7.24±0.09□□	6.81±0.10□□	6.70±0.11□□
Juiciness				

Turkey without PP (control)	6.82±0.07	6.57±0.09	6.35±0.12	6.26±0.20
Turkey with PP	6.96±0.08	7.14±0.10	6.79±0.09	6.49±0.16
Chicken with PP	6.87±0.15	7.04±0.07	6.86±0.09	7.00±0.06
Texture				
Turkey without PP (control)	6.89±0.11	6.82±0.05	6.35±0.14	6.33±0.21
Turkey with PP	7.08±0.09	7.05±0.07	6.70±0.13	6.68±0.09
Chicken with PP	7.02±0.11	7.07±0.04	6.74±0.12	6.73±0.11
Binding				
Turkey without PP (control)	7.01±0.08	6.92±0.06	6.57±0.13	6.52±0.20
Turkey with PP	7.06±0.08	7.12±0.05	6.90±0.10	6.69±0.12
Chicken with PP	7.02±0.08	7.02±0.05	6.86±0.09	6.88±0.07
Overall Palatability				
Turkey without PP (control)	6.95±0.09	6.62±0.11	6.08±0.15	5.85±0.20
Turkey with PP	7.14±0.08	7.07±0.08	6.80±0.12	6.51±0.09
Chicken with PP	6.92±0.09	7.26±0.10	6.89±0.10	6.87±0.06

n=21 * Based on 8-point descriptive scale (8 = Extremely desirable; 1 = Extremely undesirable); Means with different superscript (small letters in same row and capital letters in the same column) indicate significant difference (P< 0.05)

Loss of juiciness during frozen storage may be due to ice crystal formation, protein denaturation, and water migration. Phosphates help retain moisture by improving water-holding capacity. In aqueous phase phosphates increase ionic strength and electrostatic repulsion among the proteins, thus accommodates bound water by forming extra space which enhance water holding, reducing drip losses and cook losses. These changes improve sensory attributes and enhance economics of emulsion-based meat products (Shults and Wierbicki, 1973; Glorieux et al. 2017).

Texture scores declined during storage in all treatments, with the greatest decline observed in turkey meat slices without polyphosphate. Phosphate-treated products exhibited better textural stability. This can be attributed to enhanced protein extraction, gel formation, and improved structural integrity. Recent advancements in restructured meat technology emphasize the importance of binding systems and protein functionality in maintaining texture (Ren et al. 2024). No significant differences (P>0.05) were observed in binding scores among treatments; however, slightly lower values were recorded in control samples at later storage stages. This suggests that frozen storage did not significantly affect binding properties, though phosphates contributed to better matrix stability.

Overall palatability scores decreased gradually in all products but declined significantly (P<0.01) in turkey meat slices without polyphosphate after 60 days. No significant difference was observed between turkey and chicken slices with polyphosphate. The decline in overall palatability in control samples may be attributed to combined deterioration in appearance, flavour, juiciness, and texture. Modern sensory science supports that overall acceptability is influenced by multiple interacting factors rather than a single attribute (Yue et al. 2024). The results indicate that restructured turkey meat slices without polyphosphate were acceptable up to 30 days, whereas phosphate-treated turkey and chicken slices remained acceptable up to 90 days under frozen storage (-18±1°C).

CONCLUSIONS

The study showed that frozen storage at −18 ± 1°C well-maintained the quality and safety of restructured meat products for up to 90 days, with treatment differences observed. Polyphosphate improved physicochemical stability, as shown by higher pH and lower lipid oxidation than the control. Although TBARS increased up to 60 days, the decline at 90 days may indicate secondary reactions during prolonged storage. All products remained microbiologically safe throughout storage, with acceptable total plate counts and no coliforms or psychrotrophs detected. Sensory quality gradually declined over time, but polyphosphate-treated products, especially chicken meat slices, retained better flavour, juiciness, texture, and overall acceptability. Overall, polyphosphate enhanced shelf life and quality retention, with restructured chicken meat slices showing the best storage stability up to 90 days.

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