Food Technology Research Journal, Vol. 8, issue 2, 107-121, 2025

FTRJ

Technological Attempts to Produce Bastirma From Breast Meat of Spent Laying Hen

Nesrin, S. Mohammed, *Marwa, F. Abd El-Qader & Hala, A. Aly

Meat & Fish Technology Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

Original Article

Article information
Received 20/05/2025
Revised 23/06/2025
Accepted 25/06/2025
Published 28/06/2025
Available online
30/06/2025

Keywords:
Spent hen meat, bastirma, NaCl, KCl

ABSTRACT

This study utilized breast meat from spent laying hens to develop a healthier form of bastirma with reduced sodium and nitrite content. Spent hen meat, known for its tough texture due to high collagen levels, was processed into bastirma by replacing sodium chloride (NaCl) with varying levels of potassium chloride (KCl) and reducing sodium nitrite ($NaNO_2$) levels by 50%, partially substituting it with sodium hypophosphate. Six treatments were prepared and analyzed over 90 days of refrigerated storage (4±1°C) for chemical composition, physico-chemical properties, microbial safety and sensory quality. Results showed that replacing NaCl with KCl led to a slight increase in microbial counts; however, all samples remained within acceptable microbiological limits. Moisture, protein and fat contents decreased slightly during storage, while total volatile nitrogen and thiobarbituric acid (TBA) values increased, indicating limited spoilage. Sodium increased and nitrite levels declined during storage, with the lowest values observed in treatments with the highest substitution ratios. Sensory evaluation indicated good acceptability for all treatments except those with 60 and 75% NaCl replacement. All samples remained free from *Salmonella* spp., coliforms and yeast and mold throughout the storage period. These findings suggest that spent laying hen meat can be effectively utilized in bastirma production and that partial replacement of NaCl and $NaNO_2$ can improve the health profile of the product without compromising safety or sensory quality.

1. Introduction

Meat from spent hens is a good source of protein, enriched with omega-3 fatty acids and lower in cholesterol content, both of which have been shown to provide health-promoting benefits (Chueachuaychoo et al., 2011). Globally, the consumption of poultry and poultry products has increased due to their nutritional benefits and lower cost compared to beef. Poultry meat offers high-quality protein, essential amino acids, polyunsaturated fatty acids, vitamins, and minerals. It also contains lower levels of fat and cholesterol than beef (Zhang et al., 2016). Consequently, poultry meat products are characterized by high digestibility, palatability, and nutritional value for both children and adults. Consumer acceptance of spent hen meat varies across countries. In some regions, such as China, spent hens are regularly included in meals. In countries like Korea, India, Thailand, and Brazil, they are processed into various products such as chicken soup, snacks, and processed meat products (de Souza et al., 2011; Jin et al., 2011; Kumar et al., 2015; Sabikun et al., 2021; Sarkar et al., 2019; Sorapukdee et al., 2016). However, spent hens are generally considered less desirable than broilers due to their lower taste and aroma (Lee and Kim, 2021). Nitrite has long served as a valuable antibotulinal agent in cured meats, offering protection against *Clostridium botulinum* and other pathogens. However, its use in food has been controversial due to the potential formation of carcinogenic nitrosamines through reactions with amines in the stomach (Archer, 2002). Nevertheless, the preservation of meat using nitrites and nitrates remains critical in controlling spoilage and producing safe, palatable products that maintain good quality even at ambient temperatures (Skibsted, 2011).

Journal website: https://ftrj.journals.ekb.eg/
Published by Food Technology Research Institute, ARC
https://10.21608/ftrj.2025.442129

*Corresponding Author
Email: marwa165_farouk @yahoo.com

Sodium nitrite (50ppm) helps stabilize the characteristic pink color of meat, enhances flavor, and inhibits the production of *Clostridium botulinum* toxins (Eleiwa-Nesreen, 2003). The maximum allowable concentration of nitrite in cured beef is currently 150 mg/kg, expressed as $NaNO_2$ (Merino et al., 2016). At this level, nitrite (and nitrate) improves the color, flavor, safety, and overall quality of cured meats by reducing microbial growth, particularly *C. botulinum* (Bedale et al., 2016). The World Health Organization has set a goal to reduce global salt intake by 30% by 2025. It recommends consuming less than 5g of salt per day (equivalent to less than 2g of sodium), or approximately one heaping teaspoon for adults (Sturza & Ghendov-Moşanu, 2021; Bernardo et al., 2025). However, average global salt consumption remains much higher, estimated at 9–12g/day (Erkoyun et al., 2016). The NaCl replacement with KCl by 33 % on dry sausages was accepted by consumers. Metallic taste was not associated with the inclusion of KCl on dry sausages. The use of KCl enhanced the red colour of dry cured meat sausages. (Bernardo, et al., 2025). Consumer studies have shown that replacing up to 33% of NaCl with KCl in dry sausages is acceptable. Notably, metallic taste was not associated with KCl addition, and the substitution even enhanced the red color of the cured products (Bernardo et al., 2025). In meat products like bastirma (pastrami), high salt concentrations are essential for regulating intracellular and extracellular osmotic pressure, facilitating the removal of intracellular water, reducing water activity, and maintaining microbial balance. Additionally, salt affects the texture by enhancing meat protein solubility and exerts bacteriostatic effects at high concentrations (Uzun, 2010). Salt plays a critical role in bastirma production, ensuring microbial stability, contributing to the characteristic texture, and enhancing sensory attributes such as taste and flavor. With increasing awareness of the health risks associated with high sodium intake, there is a growing interest in developing products with reduced salt content. Strategies include shortening salting times and reducing salt concentrations to below 3%, all while maintaining product quality and consumer acceptance (Dötsch et al., 2009; Tekinşen & Doğruer, 2000; Inguglia et al., 2017). In line with this, the Turkish Ministry of Health introduced a protocol in 2021 to support sodium reduction. Notably, in 2012, the permitted salt level in bastirma was lowered from 8.5g to 7g per 100g of dry matter in the Turkish Food Codex (Erdem et al., 2017). Various approaches have been explored to develop sodium-reduced meat products, including replacing all or part of NaCl with alternative chloride salts such as KCl, $CaCl_2$, LiCl, and $MgCl_2$. Ekmekçi (2012) investigated four different salt mixtures in experimental bastirma made from beef (*Musculus longissimus dorsi*) and concluded that KCl was the most suitable NaCl substitute based on microbiological, physicochemical, and chemical evaluations. Despite the availability of sodium reduction strategies, limited research has addressed their application in bastirma production, particularly using cost-effective raw materials like spent hen meat. Therefore, this study aimed to utilize spent laying hen meat in the production of bastirma with reduced sodium and nitrite content. Different replacement levels of NaCl with KCl and partial substitution of sodium nitrite with sodium hypophosphate were evaluated for their effects on the chemical composition, microbiological safety, and sensory quality of bastirma during refrigerated storage.

2. Materials and Methods

Materials

The sample under study was breast meat obtained from two-year-old spent laying hens. The birds were purchased from a local market in Cairo, Egypt, and immediately transported in a cooled icebox to the laboratory for processing. Additional ingredients used in bastirma preparation including fresh garlic, fenugreek powder, salt, and capsicum powder were also obtained from the local Cairo market. All chemicals used in the analytical procedures were sourced from Sigma Chemical Co., USA.

Methods

1. Technological Methods

Preparation of bastirma

Bastirma was prepared following the method described by Akköse et al. (2018). Initially, breast meat from spent laying hens was separated, rinsed with tap water, and trimmed of visible fat. Four vertical knife stabs (two on each side) were made in each breast fillet to aid in curing. Samples were salted and cured using mixture of:

T1: 100% NaCl+100% $NaNO_2$ (125ppm.) +1% sugar.

T2: 15% of NaCl replaced by KCl+ 50% of $NaNO_2$ replaced by NaH_2PO_2.H2O +1% sugar.

T3:30% of NaCl replaced by KCl+50% of $NaNO_2$ replaced by NaH_2PO_2.H2O +1% sugar.

T4: 45% of NaCl replaced by KCl+50% of NaNO2 replaced by $NaH_2PO_2.H_2O$ +1% sugar.

T5: 60% of NaCl replaced by KCl+ 50% of NaNO2 replaced by $NaH_2PO_2.H_2O$ +1% sugar.

T6: 75% of NaCl replaced by KCl+50% of NaNO2 replaced by $NaH_2PO_2.H_2O$ +1% sugar.

The treated flites were wrapped and pressed for 24 hrs, following this samples were rinsed and air dried, then wrapped with thread and hanged over night then coated with 10% covering mixture consist of grounded fresh garlic, fenugreek powder, capsicum powder and salt. The prepared bastirma samples were sliced (without coating), packaged, and stored at 4°C. Samples were evaluated for quality attributes chemical, physical, physicochemical, sensory, and microbiological immediately after processing (day 0) and then monthly for three months.

2. Analytical methods

A. Proximate chemical composition

Moisture (method 985.14), crude protein (method 992.15), crude fat (method 960.39), and total ash (method 900.02 A) contents were determined following AOAC (2016) guidelines. Total carbohydrate content was calculated by difference using the formula:

Total carbohydrates (%) = 100 – (% moisture + % protein + % fat + % ash)

B. Physicochemical and Chemical Properties

pH Measurement

The pH of each treatment was measured by homogenizing 10g of sample in 100ml of distilled water for 30 seconds. Measurements were taken at 20°C using a Jenway 3510 pH meter, following the method described by Fernández-López et al. (2006).

Total volatile bases nitrogen (TVBN)

TVBN was determined as an indicator of protein decomposition, using the method described by Winton and Winton (1958).

Thiobarbituric acid (TBA) Value

Lipid oxidation was assessed by determining the TBA value according to the method of Kirk and Sawyer (1991).

C. Bacteriological Methods

Total bacterial count

Total viable bacterial counts were determined using the plate count method on nutrient agar, as described by A.P.H.A. (1976) and Difco (1984). Plates were incubated at 37°C for 48 hours.

Halophilic bacterial count

Halophilic bacteria were enumerated using procedures from A.P.H.A. (1976) and Difco (1984). Incubation was carried out at 37°C for 24 hours.

Psychrophilic bacterial count

Psychrophilic bacterial counts were performed following the standard total plate count procedure, except incubation was carried out at 8°C for 5 days, according to A.P.H.A. (1976).

Coliform bacteria

Coliform bacteria were enumerated using MacConkey agar medium, following the method of A.P.H.A. (1976). Plates were incubated at 37°C for 24–48 hours.

Staphylococcus aureus Count

Staphylococcus aureus was determined using Baird-Parker agar supplemented with egg yolk tellurite emulsion. The medium was prepared as per A.P.H.A. (1976) and Difco Manual (1984). Plates were incubated at 37 °C for 24 hours.

Proteolytic Bacteria Count

Proteolytic bacteria were enumerated using nutrient agar supplemented with 10% sterile skim milk, as described by Brock (1979) and Difco Manual (1984). Incubation was carried out at 30°C for 3 days. Plates were then flooded with 1% HCl, and colonies showing clear zones were counted as proteolytic bacteria per gram.

Detection of *Salmonella* spp.

Detection of *Salmonella* was performed according to F.A.O. (1979) using the following steps:

ml buffered peptone water and incubated at 37 °C for 16–20 hours.

- Selective Enrichment: 1ml of pre-enrichment culture was inoculated into 10ml tetrathionate broth and incubated at 35°C for 48 hours.

- Selective Plating: A loopful of enriched culture was streaked onto Salmonella-Shigella agar and incubated at 35°C for 24 hours. *Salmonella* colonies appeared black, some with a metallic sheen.

Yeast and mold counts

Yeasts and molds were counted using potato dextrose agar (PDA) acidified with 1ml of 10% tartaric acid per plate. The method followed Difco Manual (1984). Plates were incubated at 20–25°C for 5 days. Colonies were counted on days 3 and 5 and expressed as colony-forming units (CFU) per gram.

Organoleptic Evaluation

Sensory evaluation of the bastirma samples was performed based on the methods described by Das et al. (2008) and Ojagh et al. (2013). Evaluations were conducted at day 0 and throughout storage at 4°C for up to 25 days. A panel of ten trained members from the Meat and Fish Technology Research Department, Food Technology Research Institute, Giza, Egypt, assessed the samples. Attributes evaluated included: Color, Odor, Taste, Texture, Overall acceptability

A 10-point hedonic scale was used: 9–10 = Like extremely, 7–8 = Like very much, 6 = Like moderately, 5 = Neither like nor dislike, 4 = Dislike moderately, 3 = Dislike very much, 1–2 = Dislike extremely.

Sodium and Potassium content

Samples were processed and the determination of minerals were analyzed. Microwave digestor (Multiwave GO Plus 50 HZ) was used prior to spectrophotometric analysis of the samples by MP AES (Microwave Plasma -Atomic Emission Spectroscopy) (Agilent, Mulgrave, Victoria, Australia) (Hammer 2008)

Statistical Analysis

Data were analyzed using two-way Analysis of Variance (ANOVA) with SPSS software version 27 (IBM Corp., 2013), based on a completely randomized design as outlined by Steel et al. (1997). Two main factors were considered:

- Treatment formulation (varying NaCl/KCl and nitrite replacements)

- Storage period (0, 1, 2, and 3 months)

Mean values were compared using Duncan's multiple range test, and significance was set at $p < 0.05$. Results are expressed as means ± standard deviation (SD).

3. Results and Discussion

Low sodium and nitrite spent hen bastirma Production and storage

Breast bastirma was prepared by partially replacing sodium chloride (NaCl) with potassium chloride (KCl) at levels of 15%, 30%, 45%, 60%, and 75%. Additionally, the added nitrite quantity was reduced by up to 50%, with sodium hypophosphate used as a partial replacement. Samples were evaluated immediately after processing and throughout refrigerated storage at 4°C for up to 3 months.

Sensory Evaluation (Overall Acceptability)

The sensory panel results revealed that all bastirma treatments showed minor differences in overall acceptability compared to the control sample containing 100% NaCl, with all treatments generally rated as acceptable except for the one in which 75% of NaCl was replaced by KCl; this particular treatment received the lowest overall acceptability score among all groups. Notably, acceptability scores declined progressively during storage for all treatments. Despite the replacement of NaCl with KCl, no significant differences were found in the measured NaCl content between the control and treated samples, due to the chloride ion-based method used for salt determination. Additionally, a slight increase in measured NaCl content was observed in all samples over the storage period.

Moisture content

The results in Table 1 showed a consistent decrease in moisture content across all treatments during cold storage at 4°C, indicating gradual desiccation of the chicken bastirma, as similarly observed by Osheba (2003), Wahdan (1998), and Aksu et al. (2016). Moisture content varied depending on the treatment and storage duration, with higher levels of KCl substitution generally associated with lower moisture levels. The highest moisture content was recorded in the treatment containing 70% NaCl (i.e., only 30% KCl), followed by the treatment with 55% NaCl and 45% KCl. Despite these differences, all treatments maintained moisture content within the permissible limit (≤ 50%) established by the Egyptian Standard for Bastirma (1991). Notably, treatments containing 30% and 45% KCl exhibited better moisture retention and higher overall acceptability, as they were less prone to drying, which likely contributed to maintaining favorable texture and eating quality findings that align with those reported by Osheba (2003).

Table 1. Moisture content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD)

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	42.48±0.54^{eA}	37.19±0.45^{cB}	35.21±0.25^{dC}	34.60±0.60^{dD}	37.37±3.27^{e}
2	43.00±0.50^{dA}	38.39±0.48^{bB}	38.47±1.05^{bB}	37.52±0.60^{bC}	39.35±2.32^{c}
3	46.31±0.80^{aA}	39.81±0.21^{aB}	39.52±0.29^{aB}	38.07±0.02^{aC}	40.93±3.34^{a}
4	45.70±1.10^{bA}	40.04±0.06^{aB}	38.92±0.40^{bC}	35.55±0.46^{cD}	40.05±3.86^{b}
5	41.98±0.83^{eA}	37.59±0.44^{cB}	36.21±0.29^{cC}	35.89±0.65^{cC}	37.92±2.59^{d}
6	43.60±1.03^{cdA}	38.62±0.68^{bB}	36.25±0.13^{cC}	34.34±0.79^{dD}	38.20±3.67^{d}
Mean	43.85±1.80^{A}	38.61±1.14^{B}	37.43±1.71^{C}	36.00±1.51^{D}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter. Control 1NaCl: 100%,treatment2 NaCl: 85%,treatment3 NaCl: 70%, treatment4 NaCl:55%,treatment5 NaCl:40%,treatment6 NaCl:25%.

Protein Content

Protein content exhibited a gradual decrease across all treatments during cold storage at 4 ± 1 °C. as shown in Table 2. Although the decline was relatively minor in the early stages of storage, it became more noticeable over time. This reduction may be attributed to two main factors:

- Migration of soluble proteins from the meat to the bastirma surface coating.
- Loss of nitrogenous compounds due to mild protein degradation, leading to an increase in volatile nitrogen.

Similar findings have been reported by Askar et al. (1993) and Osheba (2003), who also observed slight protein losses during storage of dry-cured meat products. Interestingly, treatments containing sodium hypophosphate showed better protein stability than the control. This can be attributed to the antimicrobial effects of phosphates, which may reduce protein degradation, as previously noted by Hwang et al. (1995) and Osheba (2003). Moreover, partial protein breakdown may have contributed positively to the development of desirable texture and aroma in bastirma, a process well-documented in the literature (Toldrá & Flores, 1998; Michel et al., 2020).

Table 2. Protein content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	40.41±0.51^{abA}	40.37±0.27^{bA}	39.71±0.50^{bB}	38.20±0.80^{cC}	39.67±1.05^{b}
2	41.99±0.53^{aA}	40.88±0.42^{aA}	40.08±0.92^{abB}	39.21±0.81^{bC}	40.54±1.23^{a}
3	42.41±0.51^{aA}	40.05±0.47^{bC}	40.56±0.44^{aB}	39.97±0.38^{aC}	40.75±1.10^{a}
4	38.11±1.41^{dA}	35.84±0.60^{eC}	36.81±0.21^{dB}	34.72±0.28^{eD}	36.37±1.47^{d}
5	38.53±1.48^{dA}	36.66±0.50^{dB}	36.23±0.23^{eB}	34.12±0.88^{fC}	36.39±1.81^{d}
6	39.09±0.59^{cA}	37.94±0.40^{cB}	37.91±0.11^{cB}	35.72±0.73^{dC}	37.66±1.35^{c}
Mean	40.08±1.87^{A}	38.63±2.03^{B}	38.55±1.76^{B}	36.99±2.38^{C}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter. Control1 NaCl :100%, treatment 2 NaCl: 85%,treatment 3 NaCl:70%, ,treatment4 NaCl:55%, treatment5 NaCl: 40%, treatment 6 NaCl:25%.

Fat content

Fat content of all bastirma treatments showed a progressive decrease during refrigerated storage on a dry weight (DW) basis as shown in Table 3. This reduction may be attributed to lipid oxidation and evaporation or migration of volatile lipid degradation products, which are known to occur during prolonged storage of cured meat products. Despite this decline over time, the variations in fat content among different treatments, including the control sample, were relatively small and statistically insignificant. These findings indicate that replacing NaCl with varying levels of KCl and partial nitrite substitution did not have a pronounced effect on the fat content of the product during storage. This trend is consistent with previous studies on dry-cured meat products, where minor reductions in fat content during storage were commonly observed due to oxidative processes.

Table 3. Fat content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	7.01±0.02^{dA}	6.71±0.09^{cB}	6.32±0.09^{cC}	4.74±0.14^{bcD}	6.20±0.92^{cd}
2	7.21±0.02^{bA}	6.93±0.09^{bB}	6.12±0.08^{dC}	4.79±0.07^{bD}	6.26±0.98^{c}
3	7.23±0.04^{bA}	6.09±0.10^{dB}	5.41±0.07^{eC}	3.84±0.05^{eD}	5.64±1.28^{e}
4	7.52±0.04^{aA}	7.09±0.09^{aB}	6.42±0.09^{bC}	4.91±0.02^{aD}	6.49±1.04^{a}
5	7.09±0.01^{cA}	6.91±0.07^{bB}	6.52±0.12^{aC}	4.07±0.13^{dD}	6.15±1.27^{d}
6	7.52±0.06^{aA}	6.95±0.14^{bB}	6.31±0.09^{cC}	4.70±0.10^{cD}	6.37±1.11^{b}
Mean	7.26±0.20^{A}	6.78±0.35^{B}	6.18±0.38^{C}	4.51±0.42^{D}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter, Control 1NaCl :100%,treatment 2 NaCl: 85%,treatment 3 NaCl:70%, ,treatment4 NaCl:55%, treatment 5 NaCl:40%, treatment 6 NaCl:25%.

Ash content

The results in Table 4 indicated that ash content did not significantly differ between the control sample and most treatments, except for the sample prepared with 70% NaCl, which exhibited a slightly lower ash value. This variation may be attributed to differences in mineral salt composition and retention during processing. Furthermore, it was observed that the ash content gradually increased in all bastirma samples as the cold storage period progressed. This incremental rise may be explained by the simultaneous loss of moisture and protein, leading to a relative concentration of mineral components in the dried meat matrix. These findings are in agreement with those reported by Wahdan (1998), who noted similar behavior in cured meat products during refrigerated storage.

Table 4. Ash content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	11.14±0.02^{bD}	14.49±0.16^{bC}	14.81±0.35^{bB}	15.02±0.10^{bA}	13.86±1.66^{b}
2	10.02±0.01^{dD}	11.91±0.09^{dC}	11.05±0.52^{eB}	13.41±0.41^{dA}	11.60±1.33^{d}
3	8.71±0.55^{eD}	11.12±0.15^{eC}	11.49±0.41^{dB}	13.64±0.52^{dA}	11.24±1.86^{e}
4	10.70±0.10^{cC}	13.89±0.19^{cB}	14.00±0.65^{cAB}	14.23±0.24^{cA}	13.21±1.55^{c}
5	11.63±0.31^{aC}	14.97±0.03^{aB}	15.22±0.70^{aB}	15.93±0.18^{aA}	14.44±1.76^{a}
6	11.54±0.14^{aD}	14.00±0.09^{cC}	15.27±0.62^{aB}	15.98±0.14^{aA}	14.20±1.79^{a}
Mean	10.62±1.07^{C}	13.40±1.44^{B}	13.64±1.84^{B}	14.70±1.08^{A}	13.09±2.04

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter. Control 1NaCl :100%, treatment 2 NaCl: 85%, treatment3 NaCl:70%, ,treatment4 NaCl:55%,treatment 5 NaCl:40%, treatment6 NaCl:25%.

pH Value

The results in Table 5 showed that the pH value of bastirma decreased progressively during cold storage. This decline is likely attributed to the growth and metabolic activity of acid-producing microorganisms, such as lactic acid bacteria, which can tolerate high salt concentrations and ferment residual sugars (added at an initial level of 10%). These findings are consistent with the results reported by Askar et al. (1993) and Abd El-Tawab and El-Garhi (2019). The recorded pH values for both the control and KCl-substituted treatments demonstrated a gradual reduction with storage, reaching values of 5.58, 5.29, and 4.98 in the control and 5.05 and 4.88 in KCl-treated samples after 0, 7, and 15 days, respectively. In addition, low sodium and low nitrite bastirma formulations (containing 50% sodium hypophosphate) showed a slightly lower initial pH, which continued to decline as the proportion of KCl substitution increased. This may be attributed to the more alkaline nature of Na+ ions compared to K+, as reported by Askar et al. (1993). Interestingly, the inclusion of sodium hypophosphate appeared to slightly increase the pH, possibly due to its basic buffering properties. However, no statistically significant differences in pH values were found among the various treatments throughout storage, indicating that salt type and level had only a minor influence on pH behavior under the given conditions.

Table 5. pH value of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	$5.64±0.21^{aA}$	$5.52±0.21^{aAB}$	$5.50±0.02^{aAB}$	$5.43±0.08^{aB}$	$5.52±0.15^{a}$
2	$5.63±0.12^{aA}$	$5.50±0.03^{aAB}$	$5.47±0.14^{aAB}$	$5.39±0.03^{aB}$	$5.50±0.12^{a}$
3	$5.62±0.09^{aA}$	$5.51±0.10^{aA}$	$5.50±0.05^{aA}$	$5.09±0.66^{bB}$	$5.43±0.36^{a}$
4	$5.66±0.13^{aA}$	$5.25±0.64^{bC}$	$5.50±0.05^{aAB}$	$5.40±0.05^{aBC}$	$5.45±0.32^{a}$
5	$5.68±0.17^{aA}$	$5.50±0.09^{aB}$	$5.42±0.11^{aB}$	$5.40±0.05^{aB}$	$5.50±0.15^{a}$
6	$5.39±0.58^{bB}$	$5.64±0.12^{aA}$	$5.60±0.05^{aA}$	$5.51±0.01^{aAB}$	$5.54±0.27^{a}$
Mean	$5.60±0.25^{A}$	$5.49±0.27^{AB}$	$5.50±0.09^{AB}$	$5.37±0.27^{B}$	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter. Control 1NaCl :100%, treatment2 NaCl: 85%, treatment3 NaCl:70%, treatment4 NaCl: 55%, treatment5 NaCl: 40%,

Thiobarbituric Acid Value (TBA)

The results shown in Table 6 indicate that the TBA values of bastirma were influenced by the substitution level of NaCl, the addition of sodium hypophosphate, and 90 days of cold storage. These results show that TBA values increased with the progression of cold storage time, indicating a gradual development of lipid oxidation. These findings are in agreement with those reported by Shams Eldin et al (1988); Wahdan (1998); Osheba (2003) and Abd El-Tawab and El-Garhi (2019) and are similar to those obtained by Michel et al. (2020).

Table 6. TBA content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	$0.39±0.03^{cB}$	$0.39±0.03^{eB}$	$0.42±0.01^{eB}$	$0.49±0.07^{dA}$	$0.42±0.06^{e}$
2	$0.46±0.03^{bC}$	$0.59±0.04^{bB}$	$0.63±0.20^{bcAB}$	$0.67±0.05^{abcA}$	$0.59±0.12^{bc}$
3	$0.58±0.05^{aC}$	$0.60±0.08^{bC}$	$0.65±0.04^{abB}$	$0.70±0.07^{abA}$	$0.63±0.07^{ab}$
4	$0.44±0.04^{bcC}$	$0.45±0.03^{dC}$	$0.56±0.02^{dB}$	$0.62±0.04^{cA}$	$0.52±0.09^{d}$
5	$0.45±0.04^{bD}$	$0.52±0.08^{cC}$	$0.59±0.06^{cdB}$	$0.65±0.03^{bcA}$	$0.55±0.09^{cd}$
6	$0.58±0.06^{aB}$	$0.68±0.03^{aA}$	$0.70±0.05^{aA}$	$0.72±0.07^{aA}$	$0.67±0.07^{a}$
Mean	$0.48±0.08^{D}$	$0.54±0.11^{C}$	$0.59±0.12^{B}$	$0.64±0.09^{A}$	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter, Control 1NaCl:100%, treatment2 NaCl: 85%, treatment3 NaCl: 70%, treatment4 NaCl: 55%, treatment5 NaCl: 40%, treatment6 NaCl:25%.

Total Volatile Nitrogen (TVN)

The data presented in Table 7 illustrate the effect of NaCl substitution with KCl, the addition of 0.3% sodium hypophosphate, and cold storage duration (up to 90 days at 4°C) on the TVN values of low sodium and low nitrite bastirma. At zero time, the TVN values of all treatments were very close to the control, measuring 4.69, 4.76, 4.34, 4.34, and 4.20mg/100g, respectively. Although slight increases in TVN values were noted during storage ranging from 6.3 to 7.99g/100g after 90 days these changes were minimal and statistically insignificant. Despite the apparent increase in TVN with the replacement of NaCl by KCl and with extended cold storage time, all measured values remained well below the permissible limit established by the Egyptian standard for Bastirma (1991), which sets the maximum TVN level at 20 mg/100g. These findings align with those reported by Askar et al. (1993), who observed negligible differences in TVN between NaCl and NaCl-KCl bastirma during storage, possibly attributed to variations in moisture content. Similarly, the results are consistent with those obtained by Akköse et al. (2018). In conclusion, substitution of NaCl with KCl, along with the addition of sodium hypophosphate, does not adversely affect the TVN levels of bastirma, ensuring product safety and quality throughout storage.

Table 7. TVN content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	4.73±0.52^{aD}	5.74±0.40^{abcC}	6.41±0.40^{aB}	7.00±0.17^{bA}	5.97±0.94^{ab}
2	4.69±0.34^{aD}	4.97±0.41^{dC}	5.92±0.38^{bB}	6.44±0.35^{cdA}	5.51±0.80^{c}
3	4.76±0.50^{aD}	5.46±0.27^{cC}	6.37±0.33^{aB}	7.99±0.46^{aA}	6.15±1.31^{a}
4	4.34±0.27^{bD}	5.60±0.22^{bcC}	6.00±0.14^{bB}	6.30±0.28^{dA}	5.56±0.80^{c}
5	4.34±0.42^{bD}	6.02±0.45^{aC}	6.35±0.30^{aB}	6.72±0.35^{bcA}	5.86±1.01^{ab}
6	4.20±0.17^{bD}	5.88±0.32^{abC}	6.12±0.41^{abB}	6.86±0.29^{bA}	5.77±1.05^{bc}
Mean	4.51±0.40^{D}	5.61±0.46^{C}	6.20±0.35^{B}	6.89±0.63^{A}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter, Control 1NaCl: 100%, treatment2 NaCl: 85%, treatment3 NaCl: 70%, treatment4 NaCl: 55%, treatment5 NaCl:40%, treatment6 NaCl: 25%.

Sodium Chloride Content (NaCl)

Data presented in Table 8 show the percentage of NaCl in chicken breast bastirma samples. It is evident that the salt content remained nearly stable, despite the gradual substitution of NaCl with KCl at different levels (85%, 70%, 55%, 40%, and 25% NaCl). This phenomenon can be attributed to the method of salt determination, which measures chloride ion (Cl^-) content rather than sodium (Na^+) directly. An apparent increase in salt percentage was observed during storage, which can be explained by moisture loss and drying of the samples. As the moisture content decreases, the relative proportion of dry matter, including salt, increases. These findings are consistent with those reported by Askar et al. (1993). The measured NaCl content for all samples, including the control, ranged from 4.81% to 6.22% (w/w), which is below the maximum limit of 8% established by the Egyptian Standard for Bastirma (1991). Therefore, based on sodium chloride content, all samples complied with the permissible standard and were considered acceptable.

Sodium and Potassium Content

The results presented in Table 9 demonstrate the variation in sodium and potassium contents among the different treatments, reflecting the changes in salt composition. The control sample, made with 100% NaCl, had the highest sodium content (3.88mg/kg meat). As NaCl was progressively substituted with KCl, the sodium content decreased accordingly: 2.95 mg/kg at 15% substitution, 2.65mg/kg at 30%, 2.40 mg/kg at 45%, 2.16mg/kg at 60%, and 1.49mg/kg at 75% substitution. These findings confirm the effectiveness of NaCl replacement in reducing sodium levels. Concurrently, potassium content increased with higher substitution levels, reflecting the contribution of KCl as a potassium source.

Table 8. NaCl content of different bastirma treatments during cold storage at 4◦C±1 for 90 day (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	4.81 ± 0.64^{bB}	4.98 ± 0.55^{bB}	5.00 ± 0.43^{bAB}	5.25 ± 0.32^{cA}	5.01 ± 0.46^{b}
2	4.87 ± 0.25^{bC}	5.16 ± 0.22^{bB}	5.29 ± 0.20^{bB}	5.72 ± 0.18^{bA}	5.26 ± 0.37^{b}
3	3.51 ± 0.16^{cC}	3.70 ± 0.22^{cBC}	3.92 ± 0.31^{cB}	4.53 ± 0.40^{dA}	3.92 ± 0.47^{c}
4	5.69 ± 0.22^{aB}	5.98 ± 0.33^{aA}	6.00 ± 0.44^{aA}	6.20 ± 0.55^{aA}	5.97 ± 0.39^{a}
5	5.56 ± 0.32^{aC}	5.84 ± 0.43^{aB}	6.01 ± 0.55^{aB}	6.37 ± 0.64^{aA}	5.95 ± 0.52^{a}
6	5.72 ± 0.25^{aB}	5.98 ± 0.30^{aAB}	6.00 ± 0.35^{aA}	6.22 ± 0.42^{aA}	5.98 ± 0.34^{a}
Mean	5.03 ± 0.85^{C}	5.27 ± 0.88^{BC}	5.37 ± 0.85^{B}	5.72 ± 0.77^{A}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter, Control 1NaCl: 100%, treatment2 NaCl: 85%, treatment3 NaCl: 70%, treatment4 NaCl: 55%, treatment5 NaCl:40%, treatment6 NaCl: 25%.

Table 9. Sodium and Potassium content of control and treatments at zero time (mg/kg meat)

Treatment	Chemical Compound	
	Potassium (K)	Sodium (Na)
1	0.62	3.88
2	0.78	2.95
3	0.94	2.65
4	1.51	2.40
5	1.98	2.16
6	2.35	1.49

Control 1NaCl: 100%, treatment2 NaCl: 85%, treatment3 NaCl:70%, treatment4 NaCl: 55%, treatment5 NaCl:40%, treatment6 NaCl: 25%.

Sodium Nitrite Content

Despite decades of research confirming the safety and efficacy of nitrite salts as curing agents, nitrites are still often viewed by many as potentially toxic and undesirable food additives. Nitrite salts are commonly added to meat products to extend shelf life, enhance color, and serve as valuable anti-botulinal agents, as well as contribute to the characteristic aroma and flavor of cured meats. Phosphate compounds are frequently used as nitrite replacers in food processing. More than 30 different phosphate salts are utilized in various food products and processing methods. The results shown in Table 10 indicate that the sodium nitrite content in bastirma was affected by the substitution of KCl for NaCl, the reduction of $NaNO_2$, and the addition of sodium hypophosphate during 4 months of cold storage at 4º±1ºC and 85-90% relative humidity. It was observed that the residual nitrite levels in the samples significantly decreased as storage time increased. The most notable reduction occurred in the sixth treatment, where 75% of NaCl was replaced and $NaNO_2$ reduced by 50%. This decrease is attributed primarily to the effect of storage rather than the substitution itself. These findings align with results reported by Aksu et al. (2016), Akkose et al. (2018), Sorour et al. (2022), and Saad et al. (2013).

Microbiological Evaluation of Low Sodium Bastirma as Affected by Partial Replacement of NaCl with KCl and 90 Days of Cold Storage at 4ºC

Total Bacterial Count (TBC)

The total bacterial count of bastirma samples was determined during cold storage at 4ºC to evaluate the effect of partial replacement of NaCl with KCl. Results presented in Table 11 indicate that substituting NaCl with KCl at levels of 15%, 30%, 45%, 60%, and 75% caused a noticeable increase in total bacterial count compared to the control sample. The higher the level of NaCl replacement, the greater the bacterial count observed. At zero time, the control sample exhibited a total bacterial count of 1.50×10^3 cfu/g, while the treated samples ranged from 2.05 to 4.48 × 10^3 cfu/g. This increase is attributed to the substitution of NaCl by KCl. Throughout the cold storage period, the total bacterial count in all bastirma samples progressively increased. These findings agree with Saewan et al. (2020), who reported a significant increase ($P < 0.05$) in total plate counts of breast and thigh meat stored under refrigeration.

Halophilic Bacteria

Replacing NaCl with KCl at the tested levels resulted in only slight, negligible increases in halophilic bacteria counts. During storage at 4ºC, halophilic bacteria counts showed a progressive increase in all bastirma samples. This slight increase might be linked to the consumption of sodium nitrite during storage.

Staphylococcus aureus

Staphylococcus aureus was not detected before the 60th day of storage but appeared in very low counts during later stages. The observed counts remained below the Egyptian Standard limit of 10^3 CFU/g (2005). These results are consistent with findings by Kittur et al. (2015).

Psychrophilic Bacterial Count

Psychrophilic bacteria, which thrive at refrigeration temperatures and can cause off-flavors and spoilage (Gilliland et al., 1976), were not detected (0.0 cfu/g) in the control or treated samples at zero time or before 60 days of storage. Psychrophilic bacteria appeared only at very late storage periods, with a slight increase from days 60 to 90. This suggests that processing was performed under good sanitary and hygienic conditions. These results align with Osheba (2003), who found that psychrophilic bacterial counts in refrigerated sausage increased over time, and with Zhicheng Cai et al. (2022), who reported significant increases in psychrophilic bacteria in refrigerated fish meat.

Proteolytic Bacteria

Proteolytic bacteria were not detected at zero time or before the 60th day of cold storage. These bacteria may enter the bastirma meat from the coat during sampling and tend to appear only at very late stages of cold storage. From days 60 to 90, proteolytic bacteria counts showed a very slight increase, which could be attributed to the decrease in sodium nitrite levels during storage. These findings are consistent with Saleh et al. (2022), who observed increased proteolytic bacteria counts in refrigerated beef burger samples over extended storage periods.

Coliform, *Salmonella* Bacteria, and Yeasts and Molds Counts

The counts of coliform, *Salmonella* bacteria, and yeasts and molds in bastirma samples were evaluated as affected by partial replacement of NaCl with KCl during cold storage at 4ºC. Both the control and treated samples were free from coliform and Salmonella bacteria. These results align with Khaleghi et al. (2016) and comply with the Egyptian Organization for Standardization and Quality Control (E.O.S., 2010), which mandates that all meat products must be free of *Salmonella* and *Clostridium botulinum*. Additionally, all samples tested negative for yeasts and molds, confirming the microbiological safety of the bastirma under the tested conditions.

Table 10. Na_2NO_2 content of different bastirma treatments during cold storage at 4◦C±1 for 90 days (mean±SD).

Treatment	Storage period (month)				Mean
	0	1	2	3	
1	81.02 ± 0.68^{aA}	70.41 ± 0.46^{aB}	63.60 ± 0.15^{aC}	35.21 ± 0.08^{aD}	62.56 ± 17.72^{a}
2	73.51 ± 0.49^{aA}	63.21 ± 0.21^{aB}	57.24 ± 0.24^{aC}	27.35 ± 0.22^{bD}	55.33 ± 17.93^{b}
3	66.64 ± 0.36^{aA}	59.84 ± 0.12^{aB}	54.06 ± 0.10^{aC}	22.31 ± 0.34^{cD}	50.71 ± 17.75^{c}
4	59.21 ± 0.79^{aA}	56.32 ± 0.32^{aB}	50.68 ± 0.32^{aC}	19.23 ± 0.08^{dD}	46.36 ± 16.68^{d}
5	59.21 ± 0.21^{aA}	55.31 ± 0.20^{aB}	49.99 ± 0.01^{aC}	17.52 ± 0.12^{eD}	45.51 ± 17.22^{e}
6	56.55 ± 0.37^{aA}	52.81 ± 0.50^{aB}	47.73 ± 0.50^{aC}	15.31 ± 0.11^{fD}	43.1 ± 17.08^{f}
Mean	66.02±9.06	59.65 ± 6.02^{B}	53.88 ± 5.47^{C}	22.82 ± 6.93^{D}	

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter; A, B & C: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter, Control 1NaCl :100%, treatment2 NaCl: 85%, treatment3 NaCl: 70%, treatment4 NaCl: 55%, treatment5 NaCl: 40%, treatment6 NaCl: 25%.

Table 11. Total bacterial count, Halophilic bacteria and *Staphylococcus aureus* (cfu/g) of different bastirma treatments during cold storage at 4◦C±1 for 90 days

Storage period Treatments days	zero	30	60	90	zero	30	60	90	zero	30	60	90
Control	1.50×10^3	5.65×10^3	2.55×10^4	1.75×10^5	2.95×10^2	5.45×10^2	1.75×10^3	5.95×10^3	ND	ND	1.5×10	3.5×10
1	2.05×10^3	6.33×10^3	3.44×10^4	2.25×10^5	3.25×10^2	5.95×10^2	2.10×10^3	6.45×10^3	ND	ND	2.1×10	4.6×10
2	2.42×10^3	6.98×10^3	3.98×10^4	2.87×10^5	3.60×10^2	6.55×10^2	2.55×10^3	7.05×10^3	ND	ND	2.8×10	5.8×10
3	3.11×10^3	7.46×10^3	4.65×10^4	3.62×10^5	4.10×10^2	7.30×10^2	3.15×10^3	7.85×10^3	ND	ND	3.5×10	7.0×10
4	3.57×10^3	8.26×10^3	5.37×10^4	4.51×10^5	4.75×10^2	8.15×10^2	3.90×10^3	8.75×10^3	ND	ND	4.4×10	8.5×10
5	4.48×10^3	9.31×10^3	6.36×10^4	5.63×10^5	5.55×10^2	9.20×10^2	4.80×10^3	9.80×10^3	ND	ND	5.2×10	9.8×10

Table 12. Psychrophilic and Proteolytic bacteria (cfu/g) of different bastirma treatments during cold storage at 4 ◦C ±1 for 90 days.

Type of bacteria	Psychrophilic bacteria				Proteolytic bacteria			
Storage period days / Treatments	zero	30	60	90	zero	30	60	90
Control	ND	ND	2.24×10^2	1.42×10^3	ND	ND	3.5×10	1.85×10^2
1	ND	ND	2.99×10^2	1.97×10^3	ND	ND	4.5×10	2.65×10^2
2	ND	ND	3.84×10^2	2.64×10^3	ND	ND	6.0×10	3.15×10^2
3	ND	ND	4.79×10^2	3.53×10^3	ND	ND	7.0×10	4.25×10^2
4	ND	ND	5.84×10^2	4.55×10^3	ND	ND	8.5×10	5.75×10^2
5	ND	ND	6.95×10^2	5.36×10^3	ND	ND	9.5×10	7.35×10^2

* Coliform group, Not detected (ND), *Salmonella Spp , Not detected (ND), *Total yeast and mold, Not detected (ND)
Control NaCl 100%, treatment1 NaCl: 85%, treatment2 NaCl: 70%, treatment3 NaCl: 55%, treatment4 NaCl: 40%, treatment5 NaCl: 25%.

Organoleptic Evaluation of Different Formulas

Data presented in Table 13 illustrate that taste significantly deteriorated in treatments where NaCl was replaced by 60% and 75% KCl at zero time. These samples were rated as having poor taste compared to other treatments, which may be attributed to the relatively high KCl levels causing a bitter or unpleasant taste sensation. According to statistical analysis, the samples were grouped as follows based on taste:

- Group 1: Control (100% NaCl)
- Group 2: Treatments with 15%, 30%, and 45% KCl replacement
- Group 3: Treatments with 60% and 75% KCl replacement

Significant differences were observed between the control and all treatments for color, with the degree of difference increasing alongside the percentage of NaCl replacement (from 15% up to 75%). Regarding odor, there were significant differences between the control and all treatments; however, no significant differences were found between the different treatment groups themselves. These findings are consistent with those reported by Osheba (2013).

Table 13. Sensory evaluation of different formula (mean±SD)

Formula No.	Color	Taste	Odor	Texture	Overall acceptability
1	9.75±0.07^{a}	9.75±0.05^{a}	9.75±0.07^{a}	9.37±0.05^{a}	9.50±0.10^{a}
2	9.13±0.04^{b}	9.25±0.15^{b}	8.30±0.32^{b}	8.73±0.10^{b}	9.03±0.01^{ab}
3	9.13±0.08^{b}	8.88±0.13^{c}	8.37±0.05^{b}	8.13±0.04^{c}	8.66±0.34^{b}
4	9.25±0.12^{b}	8.88±0.01^{c}	8.63±0.09^{b}	8.25±0.12^{c}	8.84±0.22^{b}
5	8.37±0.05^{c}	7.30±0.40^{d}	8.75±0.07^{b}	8.25±0.15^{c}	7.30±0.70^{c}
6	8.63±0.37^{c}	5.01±0.05^{e}	8.63±0.49^{b}	8.25±0.05^{c}	5.92±0.08^{d}
LSD at 0.05	0.30	0.33	0.44	0.17	0.59

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter

4. Conclusion

This study demonstrated that spent laying hen meat can be successfully utilized to produce bastirma with reduced sodium and nitrite content. Partial substitution of NaCl with KCl up to 60%, combined with a 50% reduction of sodium nitrite compensated by sodium hypophosphate, maintained acceptable physicochemical, microbiological, and sensory properties. All formulations complied with safety standards, with no detection of pathogenic or spoilage microorganisms during storage. Among the tested treatments, 15% to 45% KCl replacement provided the best balance between sensory acceptance and health benefits, while higher KCl levels (≥60%) adversely impacted taste. These results highlight the potential of using spent hen meat in developing functional meat products that are cost-effective and nutritionally enhanced. Further research is encouraged to optimize formulations and extend shelf life under various storage conditions.

References

Abd El-Tawab, S., and El-Garhi, H.M. (2019). Enhancement of the quality and safety of pastrami using fermented milk permeate. Egypt. J. Food sci., 47(1):39-49.

Akkose, A., Kaban, G., Karaoglu, M.M. and Kaya,M. (2018).Characteristics of pastirama types produced from water buffalo meat. Kafkas Univ. Vet. Fak. Derg., 24(2):179-185.

Aksu, M.I., Erdemic, E. and Cakici, N. (2016). Changes in the physic-chemical and microbial quality during the production of pastirma cured with different levels of sodium nitrite. Korean J. Food Sci. An. 36(5):617-625.

A.O.A.C (2016). Official methods of analysis of the association of official analytical chemists (20th ed.). Maryland, USA.

A.P.H.A (1976). American Public Health Association Compendium of methods for the microbiological examination of foods, pp75-97. APHA, Washington, D.C., U.S.A. Kafkas Universitesi Veteriner Fakultesi Dergisi Journal.

Archer, D.L. (2002). Evidence that ingested nitrate and nitrite are beneficial to health. Journal of Food Protection, 65(5):872-875.

Askar, A., Al-Samahy, S.K., Shehata, H.A. and Tawfik, M. (1993). Bastirma and beef buillon: The effect of substituting KCl and k-lactate for sodium chloride. Fleischwirtsch, 73(3):289-292.

Bedale, W., Sindelar, J.J. and Milkowski, A.L. (2016). Dietary nitrate and nitrite: Benefits, risks, and evolving perceptions. Meat science, 120, 85-92.

Bernardo, P., Fernandes, M.J., Fernandes, M.H., Teixeira, M.P., Alfaia, C., Serrano, Patarata, L. and Fraqueza, M.J. (2025). Salt reduction strategies for dry cured meat products: The use of KCl and microencapsulated spices and aromatic plant extracts. Meat Science, 221(3):1-11.

Brock, T.D. (1979). Biology of Microorganisms. Prentice-Hall, Inc. Engle Wood Clifts, New Jersy 07632, USA, 802 P.

Chueachuaychoo, A., Wattanachant, S. and Benjakul, S. (2011). Quality characteristics of raw and cooked spent hen pectoralis major muscles during chilled storage: Effect of salt and phosphate. International Food Research Journal, 18:601-613.

Das, K.A., Anjaneyulu, A.S.R., Gadekar, Y.P., Singh, R.P. and Pragati, H. (2008). Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in cold storage. Journal of Meat Science, 80:607-614.

De Souza, K., Araujo, R., dos Santos, A., Rodrigues, C., de Faria, D., Trindade, M. (2011). Adding value to the meat of spent laying hens manufacturing sausages with a healthy appeal. Braz J. Poult Sci 13(1):57–63.

Difco-Manual (1984). Dehydration Culture Media and Reagents for Microbiological and Clinical Laboratory Procedures, Pub. Difco- Lab., Detroit's Michigan, USA. 860 p.

Dötsch, M., Busch, J., Batenburg, M., Liem, G., Tareilus, E., Mueller, R., 51 and Meijer, G. (2009). Strategies to reduce sodium consumption: a food industry perspective. Critical Reviews in Food Science and Nutrition, 49(10):841-851.

Egyptian organization for standardization and quality control (E.O.S.) (2010). Available online: https//www.slideshare.net/flash_hero/es-7136. (accessed on 6 Dec 2021).

Egyptian Standards (2005). Egyptian organization for standardization and quality. Arab Republic of Egypt.

Egyptian standard for bastirma (1991). Bastirma Egyptian standard No.1042, Egyptian organization for standardization and quality control, Ministry of Industry, Arab Republic of Egypt.

Ekmekçi, M. (2012). Tuzu Azaltılmış Pastırma Üretiminde Potasyum Klo-rür ve Kalsiyum Klorür Kullanımının Bazı Kalite Özellikleri Üzerine Etkileri. Unpublished Master's Thesis. Ankara University Institute of Science, Food Engineering Department.

Eleiwa-Nesreen, Z.H. (2003). Effect of chemical preservatives on food poisoning bacteria in some locally manufactured meat products. Ph.D. Thesis (Meat Hygiene), Fac. Vet. Med., Zagazig Univ. (Benha branch).

Erdem, Y., Akpolat T., Derici Ü., Şengül Ş., Ertürk Ş., Ulusoy Ş., Altun B. and Arıcı, M. (2017). Dietary Sources of High Sodium Intake in Turkey: SALTURK II. Nutrients, 9(9), 933.

Erkoyun, E., Sözmen, K., Bennett, K., Unal, B. and Boshuizen, H. C. (2016). Predicting the health impact of lowering salt consumption in Turkey using the DYNAMO health impact assessment tool. Public Health, 140, 228-234.

F.A.O. (1979). Manuals of food-quality control, 4, microbiological analysis. Food and Agriculture organization of the united nations. Rome., pp. C 9 – 12 and DI – 33.

Fernández-López, J., Jiménez, S., Sayas-Barberá, E., Sendra, E. and Pérez-Alvarez, J.A. (2006). Quality characteristics of ostrich (Struthio camelus) burgers. Meat science, 73(2):295-303.

Hammer, M.R. (2008). Magnetically excited microwave plasma source for atomic emission spectroscopy with performance approaching that of the inductively coupled plasma, Spectrochimica Acta, 456-464, 63B,

Hwang, Y.C., Tsai, T.C., Kuo, C.C., and Chi, S.P. (1995). Studies on the preparation of low nitrite western style emulsified sausage. Food science-

Trends Food Sci Techn, 59, 70-78.

Gilliland, S.E., Michener, H.D. and Kraft, A.A. (1976). Psychrotrophic microorganisms. In: Compendium of Methods for Microbiological Examination of Food, Speck, M. L. ed., pp. 173 – 178. American Public Health Association. Inc. Washington, D.C., USA.

Jin, S.K., Kim, I.S. Jung, H.J., Kim, D.H., Choi, Y.J., Hur, S.J. (2011). Effect of cryoprotectants on chemical, mechanical and sensorial characteristics of spent laying hen surimi. Food Bioprocess Technol 4(8):1407–1413

Khaleghi, A., Khosravi-Darani, K. and Rezaei, K. (2016). Combined Use of Black Barberry (*Berberis crataegina L.)* extract and nitrite in cooked beef sausage during the refrigerated storage. J. Agric. Sci. Technol. 18, 601–614.

Kirk, R.S. and Sawyer, R. (1991). Pearson's Composition and Analysis of Foods. 9th Edn., Longman Scientific and Technical, London, pp: 510 -511.

Kittur, B., Srinivas, Y. and Deshpande, S.R. (2015). Evaluation of leaf and stem extracts from Cassia glauca L. for antimicrobial activity. Int. J. Pure Appl. Zool. 3, 98–102.

Kumar, Y., Singh, P., Tanwar, V.K., Ponnusamy, P., Singh PK, Shukla P (2015) Augmentation of quality attributes of chicken tikka prepared from spent hen meat with lemon juice and ginger extract marination. Nutr Food Sci 45(4):606–615

Lee SH and Kim HY (2021). Comparison of quality and sensory characteristics of spent hen and broiler in South Korea. Animals, 11(9): 2565. https://doi.org/10.3390/ ani11092565

Merino, L., Darnerud, P.O., Toldrá, F. and Ilbäck, N. G. (2016). Time-dependent depletion of nitrite in pork/beef and chicken meat products and its effect on nitrite intake estimation. Food Additives & Contaminants: Part A, 33(2):186-192.

Michel, G., Mai, M.A., Mohamed, H.M.H., and Hamdy, H., (2020). Production and quality assessment of new dry cured turkey product (turkey pastirma) processed by two different types of packaging techniques (modified traditional coating and vacuum packaging). Int.J.Vet.Sci.,9 (2):291-296.

Ojagh, S.M., Shabanpour, B. and Jamshidi, A. (2013). The Effect of Different Pre-Fried Temperatures on Physical and Chemical Characteristics of Silver Carp Fish (*Hypophthalmichthys molitrix*) Nuggets". World Journal of Fish and Marine Sciences, 5(4):414-420.

Osheba, A.S. (2003). Studies on the Preparation of Some Healthy Foods. Ph.D. Thesis, Fac. Agric., Minufiya Univ., Shebin El-Kom, Egypt.

Osheba, A.S. (2013). Technological Attempts for Production of Low Sodium Smoked Herring Fish (Renga). Advance Journal of Food Science and technology, 5(6):695-706.

Saad, S.M., Edris, A.M., Ibrahim, H.M., Hassanin, F.S., and Nayel, M.S. (2013).Studies on nitrites as chemical preservative in some meat products. Banha Veterinary medical journal.24(1):298-308.

Saewan, S.A., Khidhir, Z. Kh. and Al-Bayati, M.H. (2020). The impact of storage duration and conditions on the formation of biogenic amines and microbial content in poultry meat. Iraqi Journal of Veterinary Sciences, Vol. 35, No. 1, 2021 (183-188).

Sabikun, N., Bakhsh, A., Rahman MS, Hwang Y-H, Joo S-T (2021) Evaluation of chicken nugget properties using spent hen meat added with milk fat and potato mash at different levels. J Food Sci Technol 58:2783–2791

Saleh, W.A.M., El-Desouky, A.E. , Sharoba, A.M. and Osheba, A.S. (2022). Vital Value of Coriander and Fennel Volatile Oils on Quality Beef Burger During Cryopreservation. J. of Food and Dairy Sci., Mansoura Univ., Vol. 13(7):109– 117.

Sarkar, B., Upadhyay, S., Gogoi, P., Das, A., Hazarika M, Rahman, Z., Datta A. (2019) Development and quality evaluation of instant soup mix incorporated with spent hen meat shred. Int J. Livest Res 7:24–30.

Shams El-Din, M. Nariman and Ali, M. Zoba (1988). Quality attributes and some microbiological aspects of pasterma as affected by irradiation. Agri. Res. Rev., 66(5):905-916.

Skibsted, L.H. (2011). Nitric oxide and quality and safety of muscle based foods. Official Journal of the Nitric Oxide Society, 24(4):176-183.

Skibsted, L.H. (2011). Nitric oxide and quality and safety of muscle based foods. Official Journal of the Nitric Oxide Society, 24(4):176-183.

Sorapukdee, S., Uesakulrungrueng, C., Pilasombut, K. (2016). Effects of humectant and roasting on physicochemical and sensory properties of jerky made from spent hen meat. Korean J. Food Sci Anim Resour, 36(3):326

Sorour, M.A., Mehanni, A.E., Mahmoud, E.A. and Rasha, El-Hawashy, M. (2022). Chemical preservatives and microbiological contamination of some locally processed meat products .Journal of Sohag Agriscience (JSAS), 7(1):51-59.

Steel, R., Torrie, J. and Dickey, D. (1997). Principles and procedures of Statistics: A Biometrical Approach, 3rd ed., McGraw-Hill, New York, NY.

Sturza, R. and Ghendov-Moşanu¸ A. (2021). Food, nutrition, and health in Moldova. Nutritional and Health Aspects of Food in the Balkans, 249-262.

Tekinşen, O.C. and Doğruer, Y. (2000). Her yönüyle pastırma. Selçuk Univer-sity Printery, 5.

Toldra, F. and Flores, M. (1998). The role of muscle proteases and lipases in flavor development during the processing of dry-cured ham. Crit. Rev. Food Sci., 38(4):331-352.

Uzun, T. (2010). Farklı Paketleme Tekniklerinin, Tavuk Pastırmasının Bazı Kalite Özellikleri Üzerine Etkileri. Master's Thesis. Afyon Kocatepe University, Institute of Science.

Wahdan, A.N. (1998). Some studies on processing of marine turtle meat. Ph.D. Thesis, Fac. of Agri. Al-Azhar Univ., Egypt.

Winton, A.L, and Winton, R.B. (1958). Okoloff Mangnesium Oxide Distillation Volumetric Methods. The Analysis of Food. John Wiley, New York and Hull, London, USA, 848 p.

Zhang, H., Wu, J. and Guo, X., (2016). Effects of antimicrobial and antioxidant activities of spice extracts on raw chicken meat quality. FSHW, 5:39–48.

Zhicheng Cai, Jiamei Wang, Chencheng Liu, Gu Chen, Xiaohan Sang and Jianhao Zhang. (2022). Effects of High Voltage Atmospheric Cold Plasma Treatment on the Number of Microorganisms and the Quality of Trachinotus ovatus during Refrigerator Storage. Foods 2022, 11, 2706. https://doi.org/10.3390/foods11172706