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Evaluation of storage stability and quality changes in spent hen meat powder under ambient storage conditions

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Abstract

This study evaluated the storage stability of spent hen meat powder (SHMP) prepared by raw drying, 2% lactic acid treatment followed by drying, or pressure cooking followed by drying, with or without sodium ascorbate (0.05%) and potassium sorbate (0.1%). Six treatments were packed in Aluminium Foil-Low density polyethylene (LDPE) laminate pouches and stored at $25 \pm 2^\circ\text{C}$ for 90 days. Samples were evaluated at 15-day intervals for moisture, water activity (a_w), pH, thiobarbituric acid-reactive substances (TBARS), peroxide value, free fatty acids (FFA), instrumental colour, microbiological quality and sensory characteristics. Moisture, a_w , TBARS, peroxide value and FFA increased progressively during storage, whereas pH and sensory scores showed gradual declines. Cooked powders had lower moisture, a_w and microbial counts than raw and acid-treated powders. The preservative-treated cooked powder (T6) showed lower overall TBARS, peroxide value and FFA than the corresponding untreated cooked powder (T5), while retaining high sensory scores. Coliforms and *Salmonella* were not detected in cooked treatments throughout storage. The findings indicate that pressure cooking before dehydration, combined with sodium ascorbate and potassium sorbate and high-barrier laminate packaging, improved the stability of SHMP under the tested ambient storage conditions.

Keywords: Spent hen meat powder; storage stability; lipid oxidation; microbial quality; ambient storage; shelf life

1. Introduction

The poultry sector has expanded rapidly worldwide and in India, contributing substantially to meat and egg production and playing an important role in the livestock economy (BAHS, 2025) ^[1]. This expansion has consequently resulted in the generation of large numbers of spent hens at the end of their commercial egg-laying cycle. Spent hens are comparatively less preferred for direct culinary consumption because their meat is relatively tough and fibrous, which is associated with age-related changes in connective tissue, particularly the development of mature and heat-stable collagen cross-links (Mishra *et al.*, 2015; Malav *et al.*, 2017) ^[2, 3]. The underutilization of spent hens represents both an economic challenge and an opportunity for value addition. Conversion of spent hen meat into processed products may therefore improve its utilization and create additional value from this relatively low-cost raw material. Dehydration is an effective approach for extending the shelf-life of meat by reducing moisture content and a_w , thereby limiting microbial growth and retarding several deterioration reactions (Das and Jayaraman, 2003; Modi *et al.*, 2007) ^[4, 5]. Conversion of spent hen meat into spent hen meat powder (SHMP) can consequently reduce dependence on refrigerated storage and facilitate transportation, handling and incorporation into a range of convenience food products, including soup mixes, extruded snacks, seasonings and other meat-based formulations. In addition to improving shelf stability, SHMP can serve as a concentrated source of animal protein and provide a practical means of utilizing spent hens in value-added food applications. Despite the relatively low moisture content and a_w of dehydrated meat powders, deterioration may still occur during prolonged ambient storage. Moisture absorption from the surrounding environment, lipid oxidation, hydrolytic changes, non-enzymatic browning and, under favourable conditions, microbial proliferation can adversely affect the nutritional, physicochemical and sensory quality of the product

(Das and Jayaraman, 2003; Modi *et al.*, 2007; Kharb *et al.*, 2008; Immanuel *et al.*, 2009) [4, 7]. Lipid oxidation is of particular importance in meat products because the formation of primary and secondary oxidation products can result in rancid odours and flavours and progressive loss of product acceptability. Similarly, moisture migration into a dehydrated product can increase a_w and accelerate chemical and microbiological deterioration. The application of multiple preservation hurdles may therefore be beneficial for maintaining the stability of SHMP during ambient storage. Sodium ascorbate is an antioxidant that can be incorporated to retard oxidative deterioration, whereas potassium sorbate is widely used for controlling the growth of susceptible microorganisms, yeasts and moulds in food systems (Verma and Sahoo, 2001; Choi and Chin, 2003) [8,9]. Packaging also plays a critical role in protecting low-moisture meat products from environmental factors. Aluminium foil-LDPE laminate packaging provides a relatively effective barrier against moisture, light and oxygen transfer and can consequently complement the protective effects of added preservatives (Chacko *et al.*, 2005) [10]. Although process standardization and quality evaluation of raw and cooked spent hen meat powders have been investigated (Gokulakrishnan and Selvamani, 2026) [11], information on their comprehensive storage stability, particularly under ambient conditions and in combination with antioxidant, antimicrobial and packaging interventions, remains limited. In particular, systematic evaluation of changes in physicochemical characteristics, lipid oxidation indicators such as TBARS, peroxide value and FFA, microbiological quality and sensory attributes during extended storage is needed to establish the practical stability of these products. Such information is essential for determining the suitability of SHMP as a shelf-stable, value-added protein ingredient.

Therefore, the present study was undertaken to evaluate the physicochemical, oxidative, microbiological and sensory stability of six SHMP formulations comprising raw, acid-treated and cooked meat powders, with or without sodium ascorbate and potassium sorbate, during 90 days of storage at $25 \pm 2^\circ\text{C}$. The products were packaged in Aluminium foil-LDPE laminate pouches, and changes in physicochemical properties, lipid oxidation, microbiological quality and sensory characteristics were monitored throughout the storage period. The study was intended to elucidate the influence of pre-cooking and preservative incorporation on the storage stability and quality retention of SHMP under ambient conditions.

2. Materials and Methods

2.1 Source of raw materials

Spent hens were obtained from a local layer farm and slaughtered, dressed, and deboned. Separable fat, fascia, and connective tissues were removed, and the meat was minced twice through a 4.5-mm plate using a meat mincer (Santos, France). The minced meat was packed in 150-gauge LDPE bags and stored at $-18 \pm 2^\circ\text{C}$ until further processing.

2.2 Processing Standardization of Meat Powder

Raw SHMP: Minced raw spent hen meat was spread uniformly in a single layer and dried in a temperature-controlled drying chamber at $60 \pm 1^\circ\text{C}$ for 24 h.

Acid-Treated Raw SHMP: Minced spent hen meat was immersed in a 2% lactic acid solution for 10 s and subsequently dried at $60 \pm 1^\circ\text{C}$ for 24 h.

Cooked SHMP: Minced spent hen meat was pressure-cooked at 15 psi for 30 min and subsequently dried at $60 \pm 1^\circ\text{C}$ for 20 h.

To investigate shelf-life enhancement, each powder variant was evaluated without or with preservative incorporation (sodium ascorbate-0.05% and potassium sorbate-0.1%), resulting in six distinct treatments:

T1: Raw spent hen meat powder without preservatives

T2: Raw spent hen meat powder incorporated with sodium ascorbate and potassium sorbate

T3: Acid-treated raw spent hen meat powder without preservatives

T4: Acid-treated raw spent hen meat powder incorporated with sodium ascorbate and potassium sorbate

T5: Cooked spent hen meat powder without preservatives

T6: Cooked spent hen meat powder incorporated with sodium ascorbate and potassium sorbate

2.3 Packaging and storage protocol

All six treatment samples (T1-T6) were packaged in high-barrier Aluminium foil-LDPE laminate pouches (Aluminium foil (15 μm)/LDPE (40 μm)), heat-sealed under hygienic conditions, and stored at ambient temperature ($25 \pm 2^\circ\text{C}$). Physicochemical, oxidation parameters, microbiological quality, and sensory attributes were systematically analyzed at 15-day intervals across a total storage period of 90 days (Days 0, 15, 30, 45, 60, 75, and 90).

2.4 Analytical procedures

2.4.1 Physicochemical properties

Moisture content was determined according to the standard methods of AOAC (1995) [12]. The pH was measured using a digital pH meter (Cyberscan®, pH 510, Eutech Instruments, Singapore) in a 1:5 (w/v) sample-to-distilled-water homogenate. Water activity (a_w) was measured using a water activity meter (Hygrolab 3®, Rotronic, Switzerland).

2.4.2 Lipid oxidation and FFA analysis

TBARS values were determined using the distillation method described by Tarladgis *et al.* (1960) [13] and expressed as mg c(MDA) per kg of sample. Peroxide value was determined according to the method described by Koniecko (1979) [14] and expressed as milliequivalents of peroxide per kg of fat (meq/kg fat). FFA content was determined according to the method described by Koniecko (1979) [14] and expressed as a percentage of oleic acid.

2.4.3 Instrumental colour values

Colour characteristics, including redness (a) and yellowness (b), were measured using a Lovibond® tintometer (Model F, Greenwich, UK). Hue [$\tan^{-1}(b/a)$] and chroma [$(a^2+b^2)^{1/2}$] were calculated according to Little (1975) [15] and Froelich *et al.* (1983) [16], respectively.

2.4.4 Microbiological analysis

Total plate count (TPC), coliform count, *Staphylococcus aureus* count, yeast and mould count (YMC) and *Salmonella* detection were performed according to the standard procedures described by APHA (2001) [17].

2.4.5 Sensory evaluation

Sensory evaluation was conducted by a trained sensory panel using a five-point descriptive scale. The samples were evaluated for general appearance, colour, meat odour intensity, and fineness.

2.4.6 Statistical analysis

Data obtained across six treatments and seven storage intervals were subjected to two-way analysis of variance (ANOVA) using standard statistical algorithms. Duncan's multiple range test was applied to evaluate significant

differences among treatment means and storage periods at a significance level of $P < 0.05$.

3. Results and Discussion

3.1 Physicochemical characteristics

The mean $\pm$ SE values for moisture content, water activity (a_w) and pH of SHMP during storage are presented in Table 1. Analysis of variance revealed significant differences ($P < 0.05$) among treatments and storage periods. However, no significant difference ($P > 0.05$) was observed in the interaction between treatment and storage period.

Table 1: Changes in the moisture content (%), water activity (A_w) and pH of spent hen meat powder during storage at ambient temperature for 90 days (mean $\pm$ SE)

Treatment	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
Moisture content (%)								
T1	5.02±0.27 ^{ABC}	5.28±0.53 ^{BC}	5.53±0.67 ^{BC}	5.73±0.22 ^B	6.02±0.56 ^{AB}	6.18±0.17 ^{BC}	6.37±0.38 ^{ABC}	5.73±0.17 ^Q
T2	4.82±0.51 ^{bBC}	5.08±0.24 ^{abC}	5.33±0.51 ^{abC}	5.52±0.16 ^{abBC}	5.68±0.20 ^{abBC}	5.92±0.28 ^{abC}	6.13±0.33 ^{aBCD}	5.50±0.14 ^Q
T3	6.38±0.79 ^A	6.63±0.29 ^A	6.83±0.30 ^A	6.97±0.10 ^A	7.12±0.46 ^A	7.27±0.38 ^A	7.43±0.39 ^A	6.95±0.16 ^P
T4	6.12±0.40 ^{bAB}	6.38±0.15 ^{abAB}	6.62±0.40 ^{abAB}	6.77±0.15 ^{abA}	6.93±0.28 ^{abB}	7.07±0.28 ^{abAB}	7.27±0.34 ^{aAB}	6.74±0.12 ^P
T5	4.12±0.53 ^C	4.33±0.40 ^C	4.52±0.14 ^C	4.73±0.27 ^{CD}	4.92±0.40 ^{BC}	5.08±0.42 ^{CD}	5.27±0.28 ^{CD}	4.71±0.14 ^R
T6	3.88±0.14 ^C	4.13±0.54 ^C	4.32±0.27 ^C	4.52±0.53 ^D	4.67±0.16 ^C	4.82±0.42 ^D	5.03±0.51 ^D	4.48±0.15 ^R
Overall day mean	5.06±0.24 ^t	5.31±0.22 st	5.53±0.23 ^{rs}	5.71±0.19 ^{qrs}	5.89±0.21 ^{pqr}	6.06±0.20 ^{pq}	6.25±0.21 ^p	
Water activity (A _w)								
T1	0.36±0.00 ^{eB}	0.38±0.00 ^{dB}	0.39±0.00 ^{cdB}	0.40±0.01 ^{bcB}	0.40±0.01 ^{abBC}	0.41±0.01 ^{aB}	0.41±0.00 ^{aBC}	0.39±0.00 ⁰
T2	0.36±0.01 ^{dB}	0.36±0.01 ^{dC}	0.38±0.00 ^{CB}	0.39±0.00 ^{cbB}	0.39±0.00 ^{bcC}	0.40±0.01 ^{abB}	0.41±0.01 ^{aC}	0.38±0.00 ^P
T3	0.39±0.01 ^{eA}	0.39±0.00 ^{deA}	0.41±0.01 ^{cdA}	0.42±0.01 ^{bcA}	0.42±0.00 ^{bcA}	0.43±0.01 ^{abA}	0.44±0.01 ^{aA}	0.41±0.01 ^M
T4	0.37±0.00 ^{eB}	0.38±0.00 ^{dAB}	0.39±0.01 ^{cdB}	0.40±0.01 ^{bcB}	0.41±0.01 ^{bAB}	0.41±0.00 ^{bB}	0.43±0.00 ^{aB}	0.40±0.00 ^N
T5	0.29±0.00 ^{eC}	0.31±0.01 ^{dD}	0.32±0.00 ^{cdC}	0.33±0.00 ^{bcC}	0.33±0.01 ^{bd}	0.34±0.01 ^{abC}	0.35±0.01 ^{aD}	0.32±0.00 ^Q
T6	0.29±0.00 ^{dC}	0.29±0.01 ^{dD}	0.30±0.01 ^{cdC}	0.31±0.01 ^{cdD}	0.31±0.00 ^{bcE}	0.32±0.01 ^{abd}	0.33±0.00 ^{aE}	0.31±0.00 ^R
Overall day mean	0.34±0.01 ^r	0.35±0.01 ^q	0.36±0.01 ^p	0.37±0.01 ^o	0.38±0.01 ^o	0.39±0.01 ⁿ	0.39±0.01 ^m	
pH								
T1	5.91±0.13 ^{AB}	5.87±0.10 ^{AB}	5.83±0.08 ^{AB}	5.78±0.13 ^{AB}	5.75±0.14 ^{AB}	5.71±0.11 ^{AB}	5.67±0.14 ^A	5.79±0.04 ^Q
T2	5.74±0.10 ^B	5.70±0.13 ^B	5.66±0.08 ^B	5.63±0.13 ^B	5.60±0.09 ^B	5.57±0.13 ^B	5.55±0.16 ^A	5.63±0.04 ^R
T3	5.08±0.08 ^C	5.04±0.10 ^C	5.01±0.13 ^C	4.98±0.11 ^C	4.96±0.09 ^C	4.93±0.15 ^C	4.89±0.07 ^B	4.98±0.04 ^S
T4	4.94±0.07 ^C	4.91±0.13 ^C	4.87±0.08 ^C	4.84±0.08 ^C	4.81±0.14 ^C	4.79±0.13 ^C	4.78±0.10 ^B	4.85±0.04 ^T
T5	6.17±0.11 ^A	6.13±0.08 ^A	6.11±0.13 ^A	6.06±0.08 ^A	6.02±0.09 ^A	5.99±0.14 ^A	5.95±0.11 ^A	6.06±0.04 ^P
T6	5.92±0.13 ^{AB}	5.89±0.14 ^{AB}	5.86±0.08 ^{AB}	5.83±0.10 ^{AB}	5.80±0.08 ^{AB}	5.78±0.12 ^{AB}	5.77±0.16 ^A	5.84±0.04 ^Q
Overall day mean	5.63±0.09 ^P	5.59±0.09 ^{pq}	5.56±0.09 ^{pqr}	5.52±0.09 ^{pqr}	5.49±0.09 ^{pqr}	5.46±0.09 ^{qr}	5.44±0.09 ^r	

Means with different superscripts column-wise (capital letter) and row-wise (small letter) differ significantly ($P < 0.05$)

In general, moisture content and a_w increased in all treatments with advancing storage. The overall mean moisture content and a_w of cooked SHMP without and with sodium ascorbate and potassium sorbate (T5 and T6) were significantly ($P < 0.05$) lower than those of the other treatments. A non-significant ($P > 0.05$) decrease in moisture content was observed in treatments containing sodium ascorbate and potassium sorbate (T2, T4, and T6) compared with the corresponding treatments without sodium ascorbate and potassium sorbate (T1, T3, and T5). This may be attributed to differences in moisture retention associated with the incorporated additives.

The gradual increase in moisture content during storage could be attributed primarily to moisture absorption from the surrounding environment and its permeation through the packaging material. Similar increases in moisture content during storage have been reported for squid soup powder (Chacko *et al.*, 2005) [10] and fish soup powder (Immanuel *et*

al., 2009) [7]. A non-significant ($P > 0.05$) decrease in pH was observed in all treatments with advancement of the storage period. The pH values of acid-treated raw SHMP (T3 and T4) were significantly ($P < 0.05$) lower than those of the other treatments. Treatments containing sodium ascorbate and potassium sorbate (T2, T4, and T6) had significantly ($P < 0.05$) lower overall mean pH values than the corresponding treatments without sodium ascorbate and potassium sorbate (T1, T3, and T5). The decrease in pH during storage could be attributed to chemical changes occurring in the product rather than to microbial activity (Modi *et al.*, 2007) [5]. A similar decrease in pH during ambient storage was reported by Modi *et al.* (2007) [5] in chicken kebab mix.

3.2 Lipid oxidation and FFA analysis

The mean $\pm$ SE values for TBARS, peroxide value, and FFA content of SHMP during storage are presented in Table 2.

Table 2: Changes in the TBARS value, peroxide value and FFA content of spent hen meat powder during storage at ambient temperature for 90 days (mean $\pm$ SE)

Treatment	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
TBARS value (mg malonaldehyde/kg)								
T1	0.39±0.04 ^{fAB}	0.61±0.06 ^{fBC}	0.77±0.09 ^{de}	0.92±0.03 ^{cdAB}	1.08±0.06 ^{bcAB}	1.29±0.07 ^{ab}	1.50±0.03 ^a	0.94±0.06 ^Q
T2	0.33±0.07 ^{eB}	0.52±0.05 ^{deC}	0.67±0.08 ^{cd}	0.75±0.04 ^{bcdC}	0.87±0.07 ^{bcC}	1.04±0.09 ^{ab}	1.21±0.08 ^a	0.77±0.05 ^S
T3	0.42±0.08 ^{fAB}	0.62±0.03 ^{efBC}	0.79±0.05 ^{de}	0.94±0.09 ^{cdAB}	1.11±0.04 ^{bcAB}	1.33±0.06 ^{ab}	1.55±0.08 ^a	0.97±0.06 ^Q
T4	0.34±0.02 ^{eB}	0.57±0.05 ^{deBC}	0.70±0.08 ^{cd}	0.80±0.04 ^{cdBC}	0.95±0.05 ^{bcBC}	1.12±0.06 ^{ab}	1.34±0.10 ^a	0.83±0.05 ^{RS}
T5	0.58±0.08 ^{eA}	0.79±0.04 ^{deA}	0.94±0.10 ^{cd}	1.04±0.06 ^{cdA}	1.20±0.03 ^{bcA}	1.40±0.08 ^{ab}	1.61±0.03 ^a	1.08±0.06 ^P
T6	0.49±0.06 ^{dAB}	0.71±0.03 ^{cdAB}	0.81±0.10 ^{bc}	0.89±0.04 ^{bcABC}	0.99±0.07 ^{abcBC}	1.10±0.07 ^{ab}	1.30±0.04 ^a	0.90±0.04 ^{QR}
Overall day mean	0.42±0.03 ^v	0.64±0.02 ^u	0.78±0.04 ^t	0.89±0.03 ^s	1.03±0.03 ^r	1.21±0.06 ^q	1.42±0.06 ^p	
Peroxide value (meq/kg fat)								
T1	1.54±0.15 ^f	1.84±0.10 ^{ef}	2.27±0.06 ^e	2.72±0.26 ^d	3.22±0.20 ^c	3.73±0.06 ^{bA}	4.32±0.12 ^{aA}	2.80±0.16 ^{PQ}
T2	1.43±0.13 ^f	1.76±0.30 ^{ef}	2.06±0.26 ^{de}	2.37±0.08 ^{cd}	2.70±0.16 ^{bc}	3.12±0.24 ^{abB}	3.60±0.10 ^{aC}	2.43±0.13 ^S
T3	1.59±0.18 ^f	1.90±0.13 ^{ef}	2.32±0.25 ^{de}	2.78±0.06 ^d	3.31±0.17 ^c	3.85±0.20 ^{bA}	4.49±0.08 ^{aA}	2.89±0.16 ^Q
T4	1.53±0.18 ^f	1.83±0.08 ^{ef}	2.22±0.12 ^{de}	2.60±0.11 ^{cd}	3.01±0.25 ^{bc}	3.47±0.21 ^{baB}	4.04±0.13 ^{aB}	2.67±0.14 ^{QR}
T5	1.75±0.03 ^f	2.00±0.21 ^{ef}	2.41±0.11 ^{de}	2.83±0.02 ^d	3.34±0.29 ^c	3.89±0.12 ^{bA}	4.59±0.06 ^{aA}	2.97±0.16 ^P
T6	1.69±0.13 ^f	1.92±0.26 ^{ef}	2.19±0.05 ^{de}	2.51±0.20 ^{cd}	2.83±0.18 ^{bc}	3.15±0.10 ^{bb}	3.73±0.09 ^{aBC}	2.57±0.12 ^{RS}
Overall day mean	1.59±0.06 ^v	1.87±0.08 ^u	2.24±0.07 ^t	2.64±0.06 ^s	3.07±0.09 ^r	3.53±0.08 ^q	4.13±0.07 ^p	
FFA (% oleic acid)								
T1	0.80±0.02 ^e	0.98±0.05 ^{de}	1.14±0.08 ^{dAB}	1.26±0.10 ^{cdAB}	1.45±0.13 ^{bc}	1.67±0.16 ^{ab}	1.86±0.09 ^a	1.31±0.07 ^{RS}
T2	0.76±0.15 ^d	0.95±0.13 ^{cd}	1.07±0.03 ^{cdB}	1.16±0.05 ^{bcdB}	1.30±0.07 ^{abc}	1.50±0.15 ^{ab}	1.65±0.20 ^a	1.20±0.06 ^T
T3	0.85±0.21 ^e	1.04±0.19 ^{de}	1.20±0.13 ^{cdeAB}	1.31±0.03 ^{cdAB}	1.51±0.06 ^{bc}	1.76±0.10 ^{ab}	1.94±0.15 ^a	1.37±0.07 ^{QRS}
T4	0.82±0.08 ^d	1.00±0.14 ^{cd}	1.12±0.10 ^{cdAB}	1.22±0.15 ^{bcB}	1.35±0.20 ^{bc}	1.56±0.02 ^{ab}	1.75±0.05 ^a	1.26±0.06 ^S
T5	1.00±0.02 ^e	1.19±0.08 ^{de}	1.38±0.06 ^{cdA}	1.51±0.10 ^{cdA}	1.65±0.16 ^{bc}	1.86±0.13 ^{ab}	2.03±0.18 ^a	1.52±0.07 ^{PQ}
T6	0.95±0.10 ^d	1.14±0.13 ^{cd}	1.29±0.07 ^{bcdAB}	1.36±0.02 ^{bcdAB}	1.47±0.18 ^{bc}	1.66±0.26 ^{ab}	1.82±0.20 ^a	1.38±0.07 ^{QR}
Overall day mean	0.87±0.05 ^u	1.05±0.05 ^t	1.20±0.04 ^s	1.30±0.04 ^s	1.46±0.06 ^r	1.67±0.06 ^q	1.84±0.06 ^p	

Means with different superscripts column-wise (capital letter) and row-wise (small letter) differ significantly ($P < 0.05$)

Significant ($P < 0.05$) increases in TBARS, peroxide value, and FFA content were observed in all treatments with advancement of the storage period. The overall mean TBARS value of cooked SHMP without sodium ascorbate and potassium sorbate (T5) was significantly ($P < 0.05$) higher than those of the other treatments. This could be attributed to the antioxidant activity of sodium ascorbate. A similar reduction in TBARS values following antioxidant incorporation was reported in ground chevon by Verma and Sahoo (2001) [8]. The increases in TBARS, peroxide value, and FFA content during storage could be attributed to progressive lipid oxidation and associated lipid hydrolysis.

Similar gradual increases in TBARS values during storage have been reported in shelf-stable dehydrated chicken pulav (Das and Jayaraman, 2003) [4] and dehydrated chicken kebab mix (Modi *et al.*, 2007) [5]. Precooking was also reported to increase TBA values in dehydrated meat by Kharb and Ahlawat (2010) [18]. Similarly, an increase in peroxide value during storage was reported in dehydrated chicken chunks by Hameed *et al.* (2007) [19].

3.3 Instrumental colour values

Mean $\pm$ SE values of redness and yellowness during storage of SHMP are presented in Table 3.

Table 3: Changes in the redness (a) and yellowness (b) values of spent hen meat powder during storage at ambient temperature for 90 days (mean $\pm$ SE)

Treatment	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
Redness (a)								
T1	1.25±0.06 ^A	1.27±0.06 ^A	1.28±0.06 ^A	1.30±0.06 ^A	1.33±0.06	1.33±0.06	1.37±0.06 ^A	1.31±0.02 ^P
T2	1.25±0.05 ^A	1.27±0.05 ^A	1.28±0.05 ^A	1.30±0.05 ^A	1.33±0.05	1.33±0.05	1.37±0.05	1.31±0.02 ^P
T3	1.23±0.05 ^A	1.25±0.05 ^A	1.27±0.05 ^A	1.27±0.05 ^{AB}	1.28±0.05	1.28±0.05	1.30±0.05	1.27±0.02 ^P
T4	1.23±0.06 ^A	1.25±0.06 ^A	1.27±0.06 ^A	1.27±0.06 ^{AB}	1.28±0.06	1.28±0.06	1.30±0.06	1.27±0.02 ^P
T5	0.98±0.11 ^B	1.00±0.11 ^B	1.00±0.11 ^B	1.02±0.11 ^B	1.03±0.11	1.03±0.11	1.05±0.11	1.02±0.04 ^R
T6	1.02±0.16 ^{AB}	1.05±0.16 ^{AB}	1.08±0.16 ^{AB}	1.10±0.16 ^{AB}	1.15±0.16	1.20±0.16	1.20±0.16	1.11±0.06 ^Q
Overall day mean	1.16±0.03	1.18±0.03	1.20±0.03	1.21±0.04	1.24±0.04	1.24±0.04	1.26±0.05	
Yellowness (b)								
T1	2.50±0.22 ^A	2.50±0.22 ^A	2.53±0.22 ^A	2.57±0.22 ^A	2.58±0.22 ^A	2.60±0.22 ^A	2.62±0.22 ^A	2.56±0.08 ^P
T2	2.50±0.21 ^A	2.50±0.21 ^A	2.53±0.21 ^A	2.57±0.21 ^A	2.58±0.21 ^A	2.60±0.21 ^A	2.62±0.21 ^A	2.56±0.08 ^P
T3	2.52±0.20 ^A	2.53±0.20 ^A	2.53±0.20 ^A	2.55±0.20 ^A	2.57±0.20 ^A	2.57±0.20 ^A	2.58±0.20 ^A	2.55±0.08 ^P
T4	2.52±0.20 ^A	2.53±0.20 ^A	2.53±0.20 ^A	2.55±0.20 ^A	2.57±0.20 ^A	2.57±0.20 ^A	2.58±0.20 ^A	2.55±0.08 ^P
T5	1.67±0.23 ^B	1.67±0.23 ^B	1.72±0.23 ^B	1.72±0.23 ^B	1.73±0.23 ^B	1.73±0.23 ^B	1.75±0.23 ^B	1.71±0.09 ^Q
T6	1.67±0.30 ^B	1.83±0.30 ^{AB}	1.87±0.30 ^{AB}	1.88±0.30 ^{AB}	1.92±0.30 ^{AB}	1.90±0.30 ^{AB}	1.90±0.30 ^{AB}	1.85±0.11 ^Q
Overall day mean	2.23±0.09	2.26±0.10	2.29±0.10	2.31±0.09	2.33±0.10	2.33±0.10	2.34±0.10	

Means with different superscripts column-wise (capital letter) and row-wise (small letter) differ significantly ($P < 0.05$)

There was a non-significant ($P > 0.05$) increase in redness and yellowness values in all treatments with advancing storage. The overall mean redness and yellowness values of cooked SHMP without sodium ascorbate and potassium sorbate (T5) were significantly ($P < 0.05$) lower than those of the other treatments. A significant difference ($P < 0.05$) was observed between cooked SHMP without and with sodium ascorbate and potassium sorbate (T5 and T6). However, no significant ($P > 0.05$) difference was observed between T1 and T2 or between T3 and T4.

The increase in redness and yellowness values during storage might be attributed to non-enzymatic reactions occurring in the dried products. A similar increase in redness during storage was reported in dehydrated chicken kebab mix by Modi *et al.* (2007) [5].

3.4 Microbiological characteristics

Mean $\pm$ SE values of total plate count (TPC), coliform count, *Staphylococcus aureus* count, and yeast and mould count (YMC) during storage of SHMP are presented in Table 4.

Table 4: Changes in the total plate count, coliform count, *Staphylococcus aureus* count and Yeast and mould count (log CFU/g) of spent hen meat powder during storage at ambient temperature for 90 days (mean $\pm$ SE)

Treatment	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
Total plate count (log CFU/g)								
T1	3.82±0.25 ^{ba}	3.81±0.19 ^{ba}	3.96±0.24 ^{ba}	4.14±0.28 ^{abA}	4.37±0.18 ^{abA}	4.51±0.19 ^{abA}	4.72±0.16 ^{aA}	4.19±0.09 ^P
T2	3.69±0.14 ^{ba}	3.65±0.28 ^{ba}	3.77±0.29 ^{ba}	3.97±0.15 ^{abA}	4.16±0.15 ^{abA}	4.30±0.17 ^{abA}	4.49±0.22 ^{aAB}	4.00±0.09 ^{PQ}
T3	3.44±0.14 ^{ca}	3.51±0.12 ^{ca}	3.66±0.26 ^{bcAB}	3.89±0.19 ^{abcA}	4.06±0.15 ^{abA}	4.18±0.14 ^{abA}	4.34±0.15 ^{aAB}	3.87±0.08 ^{QR}
T4	3.24±0.20 ^{cAB}	3.30±0.24 ^{cAB}	3.41±0.14 ^{bcABC}	3.67±0.19 ^{abcAB}	3.87±0.31 ^{abcAB}	4.02±0.14 ^{abAB}	4.20±0.25 ^{aABC}	3.67±0.09 ^R
T5	2.74±0.27 ^{cBC}	2.77±0.22 ^{cB}	2.94±0.28 ^{bcBC}	3.13±0.15 ^{bcBC}	3.43±0.17 ^{abcBC}	3.59±0.15 ^{abBC}	3.85±0.25 ^{aBC}	3.21±0.10 ^S
T6	2.53±0.13 ^{cC}	2.58±0.35 ^{cB}	2.72±0.29 ^{bcC}	2.92±0.27 ^{abcC}	3.23±0.17 ^{abcC}	3.42±0.19 ^{abC}	3.64±0.24 ^{aC}	3.00±0.11 ^S
Overall day mean	3.24±0.11 ^t	3.27±0.12 ^t	3.41±0.12 st	3.62±0.11 ^{rs}	3.85±0.10 ^{qr}	4.00±0.09 ^{pq}	4.21±0.10 ^p	
Coliform count (log CFU/g)								
T1	1.75±0.16 ^b	1.77±0.17 ^b	1.81±0.15 ^b	1.90±0.15 ^b	2.02±0.14 ^{ab}	2.19±0.15 ^{ab}	2.41±0.21 ^a	1.98±0.07 ^P
T2	1.61±0.10 ^b	1.62±0.14 ^b	1.67±0.15 ^b	1.74±0.21 ^{ab}	1.88±0.22 ^{ab}	2.04±0.13 ^{ab}	2.23±0.18 ^a	1.83±0.07 ^Q
T3	1.54±0.12 ^b	1.57±0.12 ^b	1.63±0.21 ^{ab}	1.71±0.14 ^{ab}	1.83±0.13 ^{ab}	1.99±0.21 ^{ab}	2.15±0.19 ^a	1.77±0.07 ^{QR}
T4	1.42±0.19 ^b	1.44±0.13 ^b	1.52±0.12 ^b	1.61±0.12 ^{ab}	1.72±0.13 ^{ab}	1.85±0.12 ^{ab}	2.02±0.15 ^a	1.65±0.06 ^R
T5	ND	ND	ND	ND	ND	ND	ND	-
T6	ND	ND	ND	ND	ND	ND	ND	-
Overall day mean	1.58±0.07 ^s	1.60±0.07 ^s	1.66±0.08 ^{rs}	1.74±0.08 ^{rs}	1.86±0.08 ^{pq}	2.02±0.08 ^{pq}	2.20±0.09 ^p	
Staphylococcus aureus count (log CFU/g)								
T1	1.92±0.14 ^A	1.85±0.14 ^A	1.87±0.12 ^A	1.94±0.12 ^A	1.99±0.15 ^A	2.10±0.13 ^A	2.06±0.12 ^A	1.96±0.15 ^P
T2	1.83±0.15 ^A	1.81±0.12 ^A	1.78±0.09 ^{AB}	1.80±0.14 ^{AB}	1.87±0.10 ^{AB}	1.96±0.08 ^{AB}	1.94±0.18 ^{AB}	1.86±0.05 ^{PQ}
T3	1.68±0.12 ^{AB}	1.59±0.13 ^{AB}	1.65±0.13 ^{ABC}	1.71±0.15 ^{ABC}	1.75±0.15 ^{ABC}	1.87±0.12 ^{AB}	1.89±0.13 ^{AB}	1.74±0.05 ^{QR}
T4	1.61±0.17 ^{AB}	1.53±0.14 ^{AB}	1.57±0.14 ^{ABC}	1.54±0.14 ^{ABC}	1.66±0.12 ^{ABC}	1.74±0.12 ^{BC}	1.71±0.17 ^{ABC}	1.62±0.05 ^R
T5	1.39±0.12 ^B	1.32±0.12 ^B	1.42±0.12 ^{BC}	1.48±0.12 ^{BC}	1.56±0.10 ^{BC}	1.53±0.12 ^C	1.56±0.13 ^{BC}	1.33±0.04 ^S
T6	1.33±0.10 ^B	1.29±0.13 ^B	1.31±0.11 ^C	1.35±0.12 ^C	1.42±0.14 ^C	1.41±0.09 ^C	1.39±0.11 ^C	1.36±0.04 ^S
Overall day mean	1.63±0.06 ^{pqr}	1.57±0.06 ^r	1.60±0.06 ^{qr}	1.64±0.06 ^{pqr}	1.71±0.06 ^{pqr}	1.77±0.06 ^p	1.76±0.07 ^{pq}	
Yeast and mould count (log CFU/g)								
T1	1.96±0.15	2.02±0.13	2.03±0.14 ^A	2.11±0.15 ^A	2.19±0.22	2.23±0.12 ^A	2.29±0.14 ^A	2.12±0.06 ^P
T2	1.88±0.25	1.87±0.13	1.85±0.11 ^{AB}	1.94±0.10 ^{AB}	2.02±0.17	2.05±0.17 ^{AB}	2.10±0.25 ^{AB}	1.96±0.06 ^{PQ}
T3	1.87±0.17	1.91±0.16	1.85±0.10 ^{AB}	1.92±0.14 ^{AB}	1.97±0.16	2.01±0.23 ^{AB}	2.07±0.22 ^{AB}	1.94±0.06 ^{PQ}
T4	1.79±0.16	1.82±0.15	1.76±0.19 ^{AB}	1.85±0.11 ^{AB}	1.84±0.20	1.89±0.11 ^{AB}	1.92±0.14 ^{AB}	1.84±0.05 ^{QR}
T5	1.65±0.11	1.70±0.14	1.66±0.12 ^{AB}	1.71±0.15 ^{AB}	1.73±0.19	1.76±0.21 ^{AB}	1.81±0.12 ^{AB}	1.72±0.05 ^{RS}
T6	1.56±0.10	1.58±0.14	1.53±0.11 ^B	1.59±0.18 ^B	1.61±0.19	1.64±0.14 ^B	1.60±0.18 ^B	1.59±0.05 ^S
Overall day mean	1.79±0.07	1.82±0.06	1.78±0.06	1.85±0.06	1.89±0.08	1.93±0.07	1.97±0.08	

Means with different superscripts column-wise (capital letter) and row-wise (small letter) differ significantly ($P < 0.05$). ND: Not detected

In general, there was a non-significant ($P > 0.05$) increase in TPC and *Staphylococcus aureus* counts in all treatments with progressive storage. The overall mean TPC of cooked SHMP without and with sodium ascorbate and potassium sorbate (T5 and T6) was significantly ($P < 0.05$) lower than that of the other treatments. A non-significant ($P > 0.05$) reduction in TPC was observed in treatments containing sodium ascorbate and potassium sorbate (T2, T4, and T6) compared with those without sodium ascorbate and potassium sorbate (T1, T3, and T5), which might be attributed to the antimicrobial activity of potassium sorbate. The antimicrobial effect of potassium sorbate has also been

reported by several workers (Babji, 1996; Choi and Chin, 2003; Thomas, 2007) [20, 9, 21].

Even after 90 days of storage, the TPC remained well below the permissible limit of 5 log₁₀ CFU/g for dried products (Jay *et al.*, 2005) [22]. The lower TPC observed in cooked SHMP might be attributed to the combined effects of thermal processing, low a_w , and hygienic practices followed during processing and storage. Similar increases in TPC during storage have been reported for squid soup powder (Chacko *et al.*, 2005) [10], chicken kebab mix (Modi *et al.*, 2007) [5], dehydrated chicken chunks (Hameed *et al.*, 2007) [19], fish soup powder (Immanuel *et al.*, 2009) [7], and

dehydrated spent hen meat mince (Kharb and Ahlawat, 2010) [18].

Similar to TPC, a progressive increase in coliform counts was observed in all treatments during storage, except in cooked SHMP (T5 and T6), in which coliforms were not detected throughout the storage period. The overall mean coliform count of raw SHMP without sodium ascorbate and potassium sorbate (T1) was significantly ($P < 0.05$) higher than that of the other treatments. A non-significant ($P > 0.05$) reduction in coliform counts was observed in treatments containing sodium ascorbate and potassium sorbate (T2 and T4) compared with those without sodium ascorbate and potassium sorbate (T1 and T3). This reduction might be attributed to the antimicrobial activity of potassium sorbate. The absence of coliforms in cooked SHMP might be attributed to thermal processing and the low a_w of the product. The lower *Staphylococcus aureus* count observed in cooked SHMP might similarly be attributed to thermal processing, low a_w , and hygienic practices followed during processing and storage. A similar increase in *Staphylococcus aureus* counts during storage was reported for dehydrated chicken pulav by Das and Jayaraman (2003) [4]. There was a non-significant ($P > 0.05$) increase in YMC

in all treatments with advancing storage. The overall mean YMC of cooked SHMP without and with sodium ascorbate and potassium sorbate (T5 and T6) was significantly ($P < 0.05$) lower than that of the other treatments. A non-significant ($P > 0.05$) reduction in YMC was observed in treatments containing sodium ascorbate and potassium sorbate (T2, T4, and T6) compared with those without sodium ascorbate and potassium sorbate (T1, T3, and T5). This reduction might be attributed to the antimicrobial activity of potassium sorbate. Similar increases in YMC during storage have been reported for dehydrated chicken chunks (Hameed *et al.*, 2007) [19] and dehydrated spent hen meat mince (Kharb and Ahlawat, 2010) [18].

Salmonella was not detected in any of the samples throughout the storage period. The absence of *Salmonella* has also been reported in squid soup powder (Chacko *et al.*, 2005) [10] and chicken emulsion (Kala *et al.*, 2007) [23].

3.5 Sensory characteristics

General appearance, colour, meat odour intensity, and fineness scores during storage of SHMP are presented in Table 5.

Table 5: Changes in the sensory scores of spent hen meat powder during storage at ambient temperature for 90 days (mean $\pm$ SE)

Treatment	Storage period (days)							Overall treatment mean
	0	15	30	45	60	75	90	
General appearance*								
T1	4.11±0.11 ^B	4.14±0.11 ^B	4.13±0.11 ^B	4.09±0.12 ^B	4.07±0.12 ^B	4.04±0.11 ^B	4.00±0.12 ^B	4.08±0.04
T2	4.13±0.13 ^B	4.15±0.14 ^B	4.12±0.14 ^B	4.12±0.13 ^B	4.13±0.14 ^B	4.11±0.13 ^B	4.08±0.13 ^B	4.12±0.05
T3	4.14±0.10 ^B	4.12±0.10 ^B	4.11±0.09 ^B	4.06±0.11 ^B	4.04±0.11 ^B	3.98±0.12 ^B	3.93±0.12 ^B	4.05±0.04
T4	4.16±0.12 ^B	4.18±0.11 ^B	4.17±0.11 ^B	4.15±0.12 ^B	4.14±0.11 ^B	4.07±0.14 ^B	4.04±0.13 ^B	4.13±0.05
T5	4.74±0.07 ^A	4.76±0.06 ^A	4.78±0.06 ^A	4.75±0.08 ^A	4.67±0.09 ^A	4.63±0.11 ^A	4.60±0.11 ^A	4.70±0.03
T6	4.73±0.06 ^A	4.70±0.06 ^A	4.72±0.05 ^A	4.70±0.07 ^A	4.69±0.07 ^A	4.66±0.07 ^A	4.65±0.07 ^A	4.69±0.02
Overall day mean	4.34±0.05	4.34±0.05	4.34±0.05	4.31±0.05	4.29±0.05	4.25±0.05	4.22±0.05	
Colour*								
T1	4.20±0.12 ^B	4.18±0.12 ^B	4.15±0.12 ^B	4.11±0.13 ^B	4.09±0.14 ^B	4.10±0.13 ^B	4.08±0.14 ^B	4.13±0.05
T2	4.19±0.10 ^B	4.20±0.10 ^B	4.19±0.10 ^B	4.17±0.10 ^B	4.17±0.10 ^B	4.18±0.10 ^B	4.16±0.11 ^B	4.18±0.04
T3	4.27±0.09 ^B	4.24±0.09 ^B	4.22±0.09 ^B	4.17±0.10 ^B	4.14±0.11 ^B	4.09±0.12 ^B	4.04±0.15 ^B	4.17±0.04
T4	4.28±0.08 ^B	4.26±0.08 ^B	4.25±0.08 ^B	4.22±0.08 ^B	4.23±0.08 ^B	4.20±0.09 ^B	4.18±0.10 ^B	4.23±0.03
T5	4.70±0.07 ^A	4.68±0.07 ^A	4.63±0.10 ^A	4.59±0.11 ^A	4.59±0.10 ^A	4.57±0.11 ^A	4.55±0.11 ^A	4.62±0.04
T6	4.68±0.07 ^A	4.67±0.07 ^A	4.65±0.08 ^A	4.64±0.08 ^A	4.61±0.08 ^A	4.63±0.07 ^A	4.62±0.08 ^A	4.64±0.03
Overall day mean	4.38±0.04	4.37±0.04	4.35±0.04	4.32±0.04	4.31±0.05	4.30±0.05	4.27±0.05	
Meat odour intensity*								
T1	3.98±0.12 ^B	3.96±0.12 ^B	3.91±0.12 ^B	3.92±0.12 ^B	3.91±0.12 ^B	3.88±0.13 ^B	3.86±0.13 ^B	3.92±0.05
T2	3.97±0.13 ^B	3.95±0.13 ^B	3.92±0.13 ^B	3.90±0.12 ^B	3.88±0.12 ^B	3.87±0.14 ^B	3.85±0.14 ^B	3.91±0.05
T3	3.90±0.11 ^B	3.87±0.10 ^B	3.83±0.10 ^B	3.78±0.09 ^B	3.75±0.10 ^B	3.72±0.10 ^B	3.67±0.10 ^B	3.79±0.04
T4	3.91±0.12 ^B	3.88±0.12 ^B	3.83±0.11 ^B	3.79±0.12 ^B	3.75±0.11 ^B	3.73±0.11 ^B	3.67±0.11 ^B	3.79±0.04
T5	4.41±0.10 ^A	4.40±0.10 ^A	4.38±0.10 ^A	4.34±0.11 ^A	4.32±0.11 ^A	4.33±0.12 ^A	4.34±0.11 ^A	4.36±0.04
T6	4.40±0.10 ^A	4.41±0.10 ^A	4.39±0.10 ^A	4.38±0.11 ^A	4.38±0.11 ^A	4.39±0.11 ^A	4.36±0.11 ^A	4.39±0.04
Overall day mean	4.10±0.05	4.08±0.05	4.04±0.05	4.02±0.05	4.00±0.05	3.99±0.05	3.96±0.05	
Fineness*								
T1	3.83±0.12 ^B	3.84±0.12 ^B	3.82±0.12 ^B	3.83±0.12 ^B	3.81±0.12 ^B	3.78±0.12 ^B	3.74±0.12 ^B	3.81±0.04 ^R
T2	3.84±0.12 ^B	3.83±0.12 ^B	3.82±0.12 ^B	3.81±0.12 ^B	3.80±0.12 ^B	3.77±0.12 ^B	3.75±0.12 ^B	3.80±0.04 ^R
T3	3.96±0.10 ^B	3.95±0.10 ^B	3.95±0.10 ^B	3.94±0.10 ^B	3.93±0.10 ^B	3.91±0.10 ^B	3.89±0.10 ^B	3.93±0.04 ^Q
T4	3.94±0.11 ^B	3.94±0.11 ^B	3.93±0.11 ^B	3.91±0.11 ^B	3.92±0.10 ^B	3.90±0.10 ^B	3.88±0.10 ^B	3.92±0.04 ^Q
T5	4.84±0.05 ^A	4.83±0.05 ^A	4.81±0.05 ^A	4.80±0.06 ^A	4.78±0.07 ^A	4.77±0.08 ^A	4.76±0.08 ^A	4.80±0.02 ^P
T6	4.83±0.05 ^A	4.82±0.05 ^A	4.82±0.05 ^A	4.79±0.07 ^A	4.77±0.07 ^A	4.75±0.08 ^A	4.76±0.08 ^A	4.79±0.02 ^P
Overall day mean	4.21±0.05	4.20±0.05	4.19±0.05	4.18±0.05	4.17±0.05	4.15±0.05	4.13±0.05	

Means bearing different superscript capital letters within a column differ significantly ($P < 0.05$). *Sensory attributes were evaluated using a 5-point descriptive scale. Higher scores indicate greater acceptability/intensity of the respective attribute

There was a non-significant ($P > 0.05$) decrease in the general appearance and colour scores of all treatments with advancing storage. The general appearance and colour scores of cooked SHMP without and with sodium ascorbate

and potassium sorbate (T5 and T6) were significantly ($P < 0.05$) higher than those of the other treatments. A non-significant ($P > 0.05$) increase in general appearance and colour scores was observed in treatments containing sodium

ascorbate and potassium sorbate (T2, T4, and T6) compared with those without sodium ascorbate and potassium sorbate (T1, T3, and T5). A similar improvement in colour score was reported in antioxidant-incorporated ground chevon by Verma and Sahoo (2001) [8].

There was a non-significant ($P > 0.05$) decrease in meat odour intensity and fineness scores in all treatments with advancing storage. The meat odour intensity and fineness scores of cooked SHMP without and with sodium ascorbate and potassium sorbate (T5 and T6) were significantly ($P < 0.05$) higher than those of the other treatments. No significant ($P > 0.05$) differences were observed between T1 and T2, T3 and T4, or T5 and T6.

The progressive decrease in meat odour intensity scores during storage might be associated with oxidative changes in the product, as reflected by the increases in TBARS values and FFA content under aerobic storage conditions (Tarladgis *et al.*, 1960) [13]. The progressive decrease in fineness scores during storage might be associated with an increase in moisture content and consequent changes in the physical characteristics of the powder.

4. Conclusion

Spent hen meat powder exhibited progressive changes in physicochemical, oxidative, microbiological and sensory characteristics during 90 days of storage at $25 \pm 2^\circ\text{C}$ in Aluminium foil-LDPE laminate pouches. Moisture content, a_w , TBARS, peroxide value and FFA content increased during storage, whereas pH and sensory scores showed gradual declines. Cooked SHMP (T5 and T6) consistently exhibited lower moisture, a_w and microbial counts than the raw and acid-treated powders. Coliforms were not detected in the cooked treatments, and *Salmonella* was not detected in any treatment throughout the storage period. Incorporation of sodium ascorbate and potassium sorbate was associated with lower oxidative and microbial changes, with preservative-treated cooked SHMP (T6) showing lower overall TBARS, peroxide value and FFA values than the corresponding untreated cooked powder (T5), while retaining favourable sensory characteristics. Under the conditions evaluated, pressure cooking followed by dehydration, combined with sodium ascorbate and potassium sorbate and high-barrier Aluminium foil-LDPE laminate packaging, supported the stability and quality retention of SHMP for 90 days of ambient storage. The findings demonstrate the potential of appropriately processed and packaged spent hen meat powder as a shelf-stable, value-added protein ingredient.

References

1. BAHS. Basic Animal Husbandry Statistics. New Delhi: Department of Animal Husbandry and Dairying, Government of India; 2025.
2. Mishra BP, Chauhan G, Mendiratta SK, Sharma BD, Desai BA, Rath PK. Development and quality evaluation of dehydrated chicken meat rings using spent hen meat and different extenders. *J Food Sci Technol*. 2015;52(4):2121-2129.
3. Malav OP, Chatli MK, Kumar P, Mehta N. Optimization and quality evaluation of spent hen meat papad incorporated with corn and black gram flour. *Indian J Poult Sci*. 2017;52(3):312-317.
4. Das H, Jayaraman S. Quality and stability of convenience dehydrated chicken pulav. *J Food Sci Technol*. 2003; 40:97-101.
5. Modi VK, Sachindra NM, Nagegowda P, Mahendrakar NS. Quality changes during storage of dehydrated chicken kebab mix. *Int J Food Sci Technol*. 2007; 42:827-835.
6. Kharb R, Ahlawat SS, Sharma DP. Shelf life of dehydrated spent hen meat mince. *Indian J Poult Sci*. 2008; 43:213-215.
7. Immanuel G, Bright SA, Palavesam A. Biochemical, microbiological and sensory assessment of fish soup powder developed from marine trash fish (*Odonus niger*). *J Nat Aquat Resour Res Dev*. 2009; 29:33-44.
8. Verma SP, Sahoo J. Synergistic effect of L-ascorbic acid and alpha-tocopherol acetate on the quality of ground chevon during storage. *J Food Sci Technol*. 2001;38(3):220-226.
9. Choi SH, Chin KB. Evaluation of sodium lactate as a replacement for conventional chemical preservatives in comminuted sausages inoculated with *Listeria monocytogenes*. *Meat Sci*. 2003; 65:531-537.
10. Chacko D, Renitta RE, Patterson J. Development of soup powder from squid (*Sepioteuthis lessoniana*) and shelf-life assessment during storage in laminated packaging material. *J Food Technol*. 2005;3(3):449-452.
11. Gokulakrishnan P, Selvamani J. Process standardization and quality evaluation of spent hen meat powder. *International Journal of Veterinary Sciences and Animal Husbandry*. 2026;11(9):123-127.
12. AOAC. Official Methods of Analysis. 16th ed. Washington, DC: Association of Official Analytical Chemists; 1995.
13. Tarladgis BG, Watts BM, Younathan MT, Dugan LR. A distillation method for quantitative determination of malonaldehyde in rancid foods. *J Am Oil Chem Soc*. 1960; 37:403-406.
14. Koniecko EK. Handbook for Meat Chemists. New Jersey: Avery Publishing Group; 1979. p. 51-52, 68-69.
15. Little AC. Off on a tangent. *J Food Sci*. 1975; 40:410-412.
16. Froelich DA, Gullet EA, Usborne WR. Effect of nitrite and salt on the colour, flavour and overall acceptability of ham. *J Food Sci*. 1983; 48:152-154.
17. APHA. Compendium of Methods for the Microbiological Examination of Foods. 4th ed. Washington, DC: American Public Health Association; 2001.
18. Kharb R, Ahlawat SS. Effect of pre-cooking and spices on quality characteristics of dehydrated spent hen meat mince. *Indian J Poult Sci*. 2010; 45:100-102.
19. Hameed RS, Kanchana S, Vennila P, Hemalatha G. Storage stability of dehydrated chicken chunks in different packaging materials. *Indian Vet J*. 2007; 84:1283-1285.
20. Babji Y. Studies on vacuum packaged goat meat and effect of organic acids and some lactic starter cultures [PhD thesis]. Izatnagar, India: Indian Veterinary Research Institute; 1996.
21. Thomas R. Development of shelf stable pork sausages using hurdle technology [PhD thesis]. Izatnagar, India: Indian Veterinary Research Institute; 2007.

22. Jay JM, Loessner MJ, Golden DA. Modern Food Microbiology. 7th ed. New Delhi: Springer India; 2005. p. 443-447.
23. Kala RK, Kondaiah N, Anjaneyulu ASR, Thomas R. Quality of chicken emulsions stored at refrigerated temperature ($4 \pm 1^{\circ}\text{C}$). Int J Food Sci Technol. 2007;42:842-851.