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Process standardization and quality evaluation of spent hen meat powder

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ABSTRACT

This study aimed to standardize the processing conditions for developing spent hen meat powder (SHMP) and evaluate its physicochemical, functional, microbiological, and sensory characteristics. SHMP was prepared from raw, 2% lactic acid-treated, and cooked spent hen meat. Drying was carried out at an optimized temperature of 60 ± 1 °C. The developed spent hen meat powders were evaluated for their quality attributes and functional properties. Cooked SHMP exhibited highest protein content (80.49%) and favourable functional and sensory characteristics. Acid treatment improved the microbiological quality compared with raw SHMP. The developed SHMP can be used as a shelf-stable, value-added protein ingredient in food formulations. This study demonstrates the potential of spent hen meat for conversion into a stable and functional food ingredient.

Keywords: Spent hen meat, Meat powder, Drying, Functional properties, Quality characteristics

1. Introduction

The poultry sector has emerged as an organized and scientifically managed sector and is one of the fastest-growing sectors of the livestock economy. India ranks fourth in chicken meat production and second in egg production globally (BAHS, 2025) [1]. Poultry meat has become a widely consumed food owing to its cost competitiveness, nutritional quality, wide availability, and relatively few religious restrictions. It contributes significantly to total meat production and constitutes an important component of non-vegetarian diets. Its high biological value, essential amino acids, fatty acids, and vitamins contribute to its widespread consumption (Biesalski, 2005) [2].

Spent hens are less preferred by consumers because of the increasing availability of broiler meat and the greater toughness of meat from older birds. With the rapid expansion of the poultry industry, the availability of culled layers and breeders has also increased, creating challenges associated with their utilization and disposal. Meat tenderness is influenced by heat-resistant collagen cross-links, which are more abundant in the meat of older birds. The development of further-processed products from spent hen meat therefore offers potential for value addition because of the relatively low cost of the raw material and its suitability for processing (Malav *et al.*, 2017) [3].

Meat is a nutrient-dense food but is highly perishable and requires energy-intensive refrigeration and cold-chain infrastructure for storage and distribution. Conversion of meat into shelf-stable forms, such as meat powder, can reduce the dependence on refrigeration, extend shelf life, and facilitate convenient storage and utilization. Meat powder can be incorporated into extruded products, soup mixes, snacks, and other convenience food formulations. Knowledge of functional properties such as bulk density, wettability, solubility, emulsifying capacity, and water and oil absorption capacities is important for determining its suitability for various food applications. Therefore, the present study was conducted to standardize the processing conditions for the preparation of raw, acid-treated, and cooked spent hen meat powder (SHMP) and to evaluate their physicochemical, functional, microbiological, and sensory characteristics.

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 low-density polyethylene (LDPE) bags and stored at -18 ± 2 °C until further processing.

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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.

Following drying, the dehydrated meat was ground using a mixer grinder and passed through a 500- μm sieve to obtain a fine SHMP powder.

2.3 Analytical procedures

2.3.1 Proximate composition

Moisture, protein, fat, and total ash contents were determined according to the standard methods of AOAC (1995) [4].

2.3.2 Physicochemical Properties

Yield was calculated based on the initial weight of raw meat. 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). Colour characteristics, including redness (a) and yellowness (b), were measured Lovibond[®] tintometer (Model F, Greenwich, UK). Hue [$\tan^{-1}(b/a)$] and chroma [$(a^2 + b^2)^{1/2}$] (Biesalski, 2005) [2] were calculated according to Little (1975) [5] and Froelich *et al.* (1983) [6], respectively.

2.3.3 Functional properties

Bulk density: Bulk density was determined by placing approximately 5 g of meat powder into a 10-mL graduated cylinder and recording the volume occupied by the sample, according to Yetismeyen and Devci (2000) [7].

Wettability: Wettability was determined according to the method described by Onwuka (2005) [8]. Briefly, 1 g of meat powder was placed in a 25-mL graduated cylinder with a diameter of 1 cm. The cylinder was inverted and clamped 10 cm above a beaker containing 500 mL of distilled water. The time required for the powder to become completely wetted was recorded as the wettability time.

Water absorption capacity (WAC): WAC was determined according to Rodriguez-Ambriz *et al.* (2005) [9]. Briefly, 100 mg of meat powder was mixed with 1000 μL of distilled water and centrifuged at 4000 rpm for 20 min at 22°C . The supernatant was decanted, and the tube was allowed to drain at a 45° angle for 10 min. WAC was expressed as the volume of water absorbed per gram of sample.

Oil absorption capacity (OAC): OAC was determined according to Lin and Zayas (1987) [10]. Briefly, 100 mg of meat powder was vortex-mixed with 1000 μL of sunflower oil for 30 s and incubated at approximately 20°C for 30 min. The mixture was then centrifuged at 8000 rpm for 10 min at 25°C . The supernatant was decanted, and the tube was allowed to drain at a 45° angle for 20 min. OAC was expressed as the volume of oil absorbed per gram of sample.

Emulsifying capacity: Emulsifying capacity was determined according to AOAC (1995) [4]. Meat powder (2 g) was blended with 100 mL distilled water for 30 s at 100 rpm. Sunflower oil was then added in

approximately 5-mL increments until emulsion breakdown occurred. Emulsifying capacity was calculated based on the amount of oil emulsified per gram of meat powder and expressed as a percentage.

Solubility: Solubility was determined according to Gong *et al.* (2008) [11], with modifications. Briefly, 1 g of meat powder (m_1) was mixed with 10 mL of distilled water at $50 \pm 1^\circ\text{C}$ for 60 s with constant stirring. A 1-mL aliquot was transferred to an aluminium can and dried at $105 \pm 2^\circ\text{C}$ for 4 h. The can was then cooled in a desiccator and weighed (m_2). Drying and weighing were repeated until a constant weight was obtained. Solubility was calculated as: Solubility (%) = $(10 \times m_2 / m_1) \times 100$

All measurements were performed in triplicate, and the mean values were used for statistical analysis.

2.3.4 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) [12].

2.3.5 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 Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA), and significant differences among treatment means were determined using Duncan's multiple range test at a significance level of $P < 0.05$.

3. Results and Discussion

3.1 Proximate composition

The results of the proximate composition of spent hen meat powder (SHMP) are presented in Table 1. The moisture content of acid-treated raw SHMP was significantly higher ($P < 0.05$) than that of raw and cooked SHMP. In contrast, the protein content of cooked SHMP was significantly higher ($P < 0.05$) than that of raw and acid-treated raw SHMP.

The fat and ash contents of raw and acid-treated raw SHMP were comparable, but were significantly higher ($P < 0.05$) than those of cooked SHMP. The relatively lower fat and ash contents observed in cooked SHMP may be attributed to the loss of fat and soluble mineral components during precooking and subsequent drying (Loesecke, 1998) [13].

Acid treatment significantly ($P < 0.05$) reduced the protein content and increased the moisture content compared with raw SHMP. The higher moisture content of acid-treated raw SHMP may be associated with increased water retention following acid treatment, whereas the lower protein content may be attributable to the corresponding increase in moisture content.

The relatively higher protein content of cooked SHMP may be attributed to the loss of moisture and fat during precooking and subsequent drying, resulting in a relative concentration of protein in the final product. Similarly, Kharb and Ahlawat (2010) [14] reported that the moisture content was lowest in precooked dehydrated spent hen meat ($4.76 \pm 0.42\%$) and highest in raw spiced dehydrated spent hen meat mince ($6.20 \pm 0.47\%$).

Table 1. Proximate composition and physicochemical characteristics of spent hen meat powder (mean $\pm$ SE).

Parameter	Raw SHMP	Acid-treated raw SHMP	Cooked SHMP
Moisture (%)	4.95 $\pm$ 0.14 ^b	6.85 $\pm$ 0.45 ^a	4.04 $\pm$ 0.56 ^c
Protein (%)	77.07 $\pm$ 0.44 ^b	76.07 $\pm$ 0.49 ^c	80.49 $\pm$ 0.78 ^a
Fat (%)	11.09 $\pm$ 0.34 ^a	11.03 $\pm$ 0.27 ^a	8.75 $\pm$ 0.36 ^b
Ash (%)	5.18 $\pm$ 0.18 ^a	5.09 $\pm$ 0.16 ^a	4.80 $\pm$ 0.12 ^b
Yield (%)	25.17 $\pm$ 0.45 ^b	26.05 $\pm$ 0.42 ^a	25.07 $\pm$ 0.58 ^b
pH	5.91 $\pm$ 0.12 ^b	5.20 $\pm$ 0.12 ^c	6.17 $\pm$ 0.13 ^a
Water activity	0.36 $\pm$ 0.00 ^b	0.39 $\pm$ 0.01 ^a	0.29 $\pm$ 0.00 ^c
Redness (a)	1.25 $\pm$ 0.02 ^a	1.20 $\pm$ 0.09 ^{ab}	0.95 $\pm$ 0.11 ^c
Yellowness (b)	2.50 $\pm$ 0.22 ^a	2.50 $\pm$ 0.22 ^a	1.50 $\pm$ 0.22 ^b
Hue	54.64 $\pm$ 0.76 ^a	55.00 $\pm$ 0.83 ^a	52.21 $\pm$ 0.51 ^b
Chroma	2.80 $\pm$ 0.20 ^a	2.78 $\pm$ 0.22 ^a	1.78 $\pm$ 0.25 ^b

Note: Values bearing different superscript letters within a row differ significantly ($P < 0.05$).

3.2 Physicochemical characteristics

The results for physicochemical characteristics, including yield, pH, water activity, and colour parameters (redness, yellowness, hue, and chroma), are presented in Table 1.

The yields of raw and cooked SHMP were comparable but were significantly lower ($P < 0.05$) than that of acid-treated raw SHMP. The relatively higher yield of acid-treated raw SHMP may be associated with changes in pH and the higher moisture content of the final product. The pH of cooked SHMP was significantly higher ($P < 0.05$) than that of raw and acid-treated raw SHMP, whereas acid-treated raw SHMP exhibited the lowest pH. The lower pH of acid-treated raw SHMP can be attributed to the acidic nature of lactic acid. A similar decrease in pH following acid treatment was reported in hurdle-treated chevon keema by Karthikeyan *et al.* (2000) [15].

The water activity of acid-treated raw SHMP was significantly higher ($P < 0.05$) than that of raw and cooked SHMP. The higher water ac-

tivity of acid-treated raw SHMP may be associated with its higher moisture content. A similar increase in water activity with increasing moisture content has been reported by Ozilgen (2011) [16].

The redness (a) and yellowness (b) values of raw and acid-treated raw SHMP were comparable but were significantly higher ($P < 0.05$) than those of cooked SHMP. The lower colour values observed in cooked SHMP may be associated with heat-induced changes in meat pigments, particularly myoglobin, during cooking. The hue values of raw and acid-treated raw SHMP were also comparable but were significantly higher ($P < 0.05$) than those of cooked SHMP. A similar trend was observed for chroma values, with raw and acid-treated raw SHMP showing significantly higher values than cooked SHMP.

3.3 Functional properties

The functional properties of SHMP, including bulk density, wettability, OAC, WAC, emulsifying capacity, and solubility, are presented in Table 2.

Table 2. Functional properties of spent hen meat powder (mean $\pm$ SE).

Parameter	Raw SHMP	Acid-treated raw SHMP	Cooked SHMP
Bulk Density (g/mL)	0.92 $\pm$ 0.03 ^b	0.94 $\pm$ 0.02 ^a	0.81 $\pm$ 0.03 ^c
Wettability (s)	45.83 $\pm$ 0.31 ^a	42.83 $\pm$ 0.31 ^b	20.33 $\pm$ 0.42 ^c
Oil absorption capacity (mL/g)	1.72 $\pm$ 0.27 ^a	1.67 $\pm$ 0.16 ^a	0.87 $\pm$ 0.12 ^b
Water absorption capacity (mL/g)	1.83 $\pm$ 0.25 ^b	2.08 $\pm$ 0.40 ^a	2.13 $\pm$ 0.53 ^a
Emulsifying capacity (%)	72.03 $\pm$ 0.30 ^c	74.01 $\pm$ 0.25 ^b	78.35 $\pm$ 0.22 ^a
Solubility (%)	20.08 $\pm$ 0.54 ^c	26.08 $\pm$ 0.40 ^b	41.08 $\pm$ 0.62 ^a

Note: Values bearing different superscript letters within a row differ significantly ($P < 0.05$).

The bulk density of acid-treated raw SHMP was significantly higher ($P < 0.05$) than that of raw and cooked SHMP. The higher bulk density of acid-treated raw SHMP may be associated with differences in particle characteristics and its higher moisture content. Wettability time was significantly lower ($P < 0.05$) for cooked SHMP than for raw and acid-treated raw SHMP, indicating faster wetting of the cooked powder. The lower wettability time of cooked SHMP may be associated with its lower fat content and altered surface characteristics following cooking. A similar reduction in wettability time was reported for mushroom-whey soup powder by Singh *et al.* (2003) [17].

The OAC of raw and acid-treated raw SHMP was comparable, but both exhibited significantly higher ($P < 0.05$) values than cooked SHMP. The higher OAC of raw and acid-treated raw SHMP may be related to differences in protein structure and the availability of hydrophobic binding sites among the treatments.

The WAC of acid-treated raw and cooked SHMP was comparable, but both exhibited significantly higher ($P < 0.05$) values than raw SHMP.

The higher WAC of acid-treated raw and cooked SHMP may be associated with their lower fat content and increased availability of water-binding sites following acid treatment and heating. Similar increases in water absorption have been associated with the availability of additional water-binding sites in modified protein subunits following processing (Ali *et al.*, 2011) [18].

The emulsifying capacity of cooked SHMP was significantly higher ($P < 0.05$) than that of raw and acid-treated raw SHMP. The higher emulsifying capacity of cooked SHMP may be associated with its higher protein content and lower fat content, which may facilitate protein adsorption at the oil-water interface.

The solubility of cooked SHMP was significantly higher ($P < 0.05$) than that of raw and acid-treated raw SHMP. The higher solubility of cooked SHMP may be associated with heat-induced changes in protein structure and increased exposure of hydrophilic groups, thereby facilitating interaction with water.

3.4 Microbiological characteristics

The microbiological characteristics of SHMP, including TPC, coliform count, *S. aureus* count, YMC, and detection of *Salmonella*, are presented in Table 3. Significant differences ($P < 0.05$) were observed among the treatments for TPC, coliform count, *S. aureus* count, and YMC. The TPC, *S. aureus* count, and YMC of cooked SHMP were significantly lower ($P < 0.05$) than those of raw and acid-treated raw SHMP, while coliforms were not detected in cooked SHMP. The reduction in microbial counts in cooked SHMP may be attributed primarily to the thermal destruction of microorganisms during cooking prior to drying, as reported by Kharb *et al.* (2008) [19]. The microbial counts of acid-treated raw SHMP were significantly lower ($P < 0.05$) than those of raw SHMP. This reduction may be attributed to the antimicrobial activity of lactic acid, which can inhibit or reduce the growth of microorganisms (Masniyom *et al.*, 2007) [20].

The coliform count of raw SHMP was significantly higher ($P < 0.05$) than that of acid-treated raw SHMP, whereas coliforms were not detected in cooked SHMP. The absence of detectable coliforms in cooked SHMP may be associated with the combined effects of thermal processing, the low water activity of the final product, and hygienic practices during processing. Similar absence of coliforms has been reported in dehydrated chicken pulao and chicken kebab mix by Das and Jayaraman (2003) [21] and Modi *et al.* (2007) [22], respectively.

Salmonella was not detected in any of the SHMP samples. In addition, the raw meat mince used for powder preparation was negative for *Salmonella*. Similar absence of detectable *Salmonella* has been reported in squid soup powder and chicken emulsion by Chacko *et al.* (2005) [23] and Kala *et al.* (2007) [24], respectively.

Table 3. Microbiological and sensory characteristics of spent hen meat powder (mean $\pm$ SE).

Parameter	Raw SHMP	Acid-treated raw SHMP	Cooked SHMP
TPC (log cfu/g)	3.80 $\pm$ 0.37 ^a	3.48 $\pm$ 0.26 ^b	2.75 $\pm$ 0.13 ^c
Coliform count (log cfu/g)	1.80 $\pm$ 0.30 ^a	1.53 $\pm$ 0.26 ^b	ND
<i>S. aureus</i> count (log cfu/g)	1.95 $\pm$ 0.29 ^a	1.65 $\pm$ 0.13 ^b	1.36 $\pm$ 0.26 ^c
YMC (log cfu/g)	1.99 $\pm$ 0.13 ^a	1.85 $\pm$ 0.26 ^b	1.67 $\pm$ 0.18 ^c
<i>Salmonella</i>	ND	ND	ND
General appearance*	4.12 $\pm$ 0.11 ^b	4.15 $\pm$ 0.10 ^b	4.75 $\pm$ 0.07 ^a
Colour*	4.18 $\pm$ 0.12 ^b	4.34 $\pm$ 0.11 ^b	4.68 $\pm$ 0.07 ^a
Meat odour intensity*	3.94 $\pm$ 0.13 ^b	3.86 $\pm$ 0.12 ^b	4.38 $\pm$ 0.10 ^a
Fineness*	3.80 $\pm$ 0.13 ^b	3.95 $\pm$ 0.10 ^b	4.82 $\pm$ 0.05 ^a

Note: ND = not detected. *Sensory scores were assigned on a five-point descriptive scale. Different superscript letters within a row indicate significant differences ($P < 0.05$).

3.5 Sensory characteristics

The sensory characteristics of SHMP, including general appearance, colour, meat odour intensity, and fineness, are presented in Table 3.

The scores for general appearance, colour, meat odour intensity, and fineness of raw and acid-treated raw SHMP were comparable to each other but were significantly lower ($P < 0.05$) than those of cooked SHMP. The significantly higher ($P < 0.05$) scores for general appearance and colour observed in cooked SHMP may be associated with combined effects of precooking and the shorter drying time. This finding is in agreement with Kharb *et al.* (2008) [19], who reported that prolonged heat treatment resulted in a reduction in colour scores. Kharb *et al.* (2008) [19] also reported no deterioration in flavour scores when the temperature of precooked minced meat did not exceed 60 °C during drying. The higher fineness score observed for cooked SHMP may be associated with its lower moisture content and differences in the physical characteristics of the powder.

4. Conclusion

This study established processing conditions for converting spent hen meat into a shelf-stable, high-protein functional powder. Among the processing treatments, cooked SHMP exhibited the highest protein content and favorable nutritional, functional, microbiological, and sensory characteristics compared with raw and acid-treated raw SHMP. With a protein content of 80.49% and favorable emulsifying and water-binding properties, cooked SHMP shows potential as a value-added protein ingredient for incorporation into convenience foods and meat-based product formulations. The findings demonstrate the potential of processing spent hen meat into a stable, functional ingredient, thereby providing an approach for its effective utilization and value addition.

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