Agric Res (December 2016) 5(4):391–397
DOI 10.1007/s40003-016-0219-5

FULL-LENGTH RESEARCH ARTICLE

Storage Quality and Shelf Life of Functional Restructured Spent Hen Meat Blocks in Vacuum Packaging at Refrigerated Storage (4 ± 1 °C)

Swati Gupta[1] · B. D. Sharma[2]

Received: 5 July 2015 / Accepted: 24 June 2016 / Published online: 8 August 2016

Abstract The present study was conducted to study the storage quality of vacuum-packaged functional restructured spent hen meat blocks at refrigeration temperature. Slices of control and functional restructured spent hen meat block (FRSHMB) were vacuum-packaged and analysed at regular interval of 15 days at refrigerated temperature (4 ± 1 °C). The pH of control as well as FRSHMB decreased significantly from 30th day of storage. The pH of FRSHMB was significantly lower as compared to the control on the 45th and 60th day of storage. The TBA values of FRSHMB were significantly lower as compared to the control on the 30th, 45th and 60th day of storage. There was a significant increase in standard plate count of both control and FRSHMB with increase in the storage period. Psychrophils were observed on 15th day of storage, whereas anaerobes were detected on 30th day of storage and thereafter increased significantly at each successive storage interval in both control and FRSHMB. Sensory quality of control and FRSHMB was affected from 30th day onwards. All the sensory attributes rated between good to very good up to 45 days of storage. Products became unacceptable due to off flavour and higher microbial load than the permissible limit on the 60th day of storage. The study revealed that functional restructured spent hen meat blocks could be stored safely in vacuum packaging for 45 days at refrigeration temperature (4 ± 1 °C).

Keywords Microbial load · Restructured meat · Spent hen · Storage · Vacuum packaging

Introduction

Modern consumers are seeking nutritious, healthful, tasty, convenient and safe foods. Health conscious consumers have made functional foods the leading trends in the food industry. Utilization of functional ingredients is one approach to the development of functional meat products. Functional ingredients such as vegetable proteins, dietary fibres, herbs and spices can be directly incorporated into meat products during processing to improve their functional value for consumers [24]. Delivering health benefits by blending foods naturally high in nutrients and phytochemicals to achieve an end health benefit is clearly the most viable functional food strategy.

With the rapid growth in poultry sector, availability of layers and broiler hens as culls has increased, which could be beneficially utilized for product processing for the benefit of producer and consumer [13]. Spent hens are considered as by-products of the egg industry and the meat obtained from these birds is generally tough, less tender and less juicy because of high collagen content [1] and high degree of cross-linkages. Spent hen meat poses serious problems with regard to both processing and utilization. There is a need for this major resource to be used more

✉ Swati Gupta
gswati24@yahoo.com

B. D. Sharma
dr_bdsharma@yahoo.com

[1] Department of Livestock Products Technology, Vanbanndhu College of Veterinary Science & A.H., Navsari Agricultural University, Navsari, Gujarat 396 450, India

[2] Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar, Bareilly, U.P. 243 122, India

efficiently and profitably, and the utilization of spent hen meat is of prime interest to the poultry industry. Restructuring of meat is one of the innovative and process-friendly technologies around the world. The restructuring of meat and meat products enables the use of less valuable meat components to produce palatable meat products at reduced cost. The demand of health conscious consumer for convenient, highly nutritious and healthy meat products can be fulfilled satisfactorily by supply of various restructured meat products.

Consumers who demand for improved quality and extended shelf life for packaged foods are placing greater and greater demands on the performance of food packaging. There are a number of factors such as handling of the raw materials, addition of non-meat ingredients and processing conditions that may influence quality of the meat product. The microbial growth in meat depends on microbial contamination and the physico-chemical properties of meat such as moisture, pH, salt content, availability of oxygen, storage temperature, heat treatment, water activity and redox potential [21]. Packaging is an important tool to extend the shelf life of a product. Packaging materials serve as vapour barrier and prevent entry of oxygen into the package and loss of water from the food. Improved method of packaging such as vacuum packaging, modified atmospheric packaging and retail packaging is in use to extend the shelf life of fresh and processed meat products.

Vacuum packaging is defined as "the packaging of a product in a high barrier package from which air is removed to prevent growth of aerobic spoilage organisms, shrinkage, oxidation and color deterioration" [8]. The shelf life of meat under vacuum depends on the interaction of several variables. Temperature and the microbiological status of the meat at the time of packaging are the most important. Temperature has a significant effect on the oxygen-transmission rate of packaging films. During refrigeration, the vacuum allows the shelf life of the meat to be extended by reducing oxidation and the growth of aerobic microorganisms [16].

The characteristic microbial population developing in meat and meat products depends on the effect of the environmental conditions on the growth of the native microflora or of those microorganisms introduced due to contamination during handling and processing. Other major parameters are qualitative composition of microflora, water activity of samples and residual atmosphere in the vacuum packs.

Studies on vacuum-packaged restructured spent hen meat products are still scanty. Keeping in view all the above facts, the present study was undertaken to study the storage quality of vacuum-packaged functional restructured spent hen meat blocks at refrigeration temperature.

Materials and Methods

Materials

Live spent hens (White leghorn) were procured from Central Avian Research Institute (CARI), Izatnagar, Bareilly, India. They were dressed and deboned manually in the experimental abattoir of the Division of Livestock Product Technology, Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly. Deboned meat was packaged in clean polyethylene bags and frozen at −20 °C until use. Analytical and food-grade chemicals were procured from firms like Qualigens, Mercks, BDH and S.D. fine. Refined salt (Tata Chemicals Ltd., Mumbai), refined wheat flour (*maida*), potato, texturized soy protein (TSP), barley flour, oat meal, onion and garlic were procured from local market of Bareilly. Whey protein concentrate (WPC) was procured form Mahaan Proteins Ltd., New Delhi. To prepare condiment, onion and garlic were peeled off, cut into small pieces and homogenized in a mixer in 3:1 ratio to obtain a fine paste. Spices were prepared as per pre-standardized formulation in laboratory. Multilayered nylon barrier film pouches of 150 μ thickness in natural colour were procured from M/s Hitkari Industries Ltd., New Delhi.

Product Preparation

The method for the preparation of control and functional restructured spent hen meat blocks was standardized by using different proportions of ingredients for different time and temperature, and the final formulation is given in Table 1. Spent hen meat was cut manually into 1–1.5 cm^2 small chunks and massaged in paddle mixer (HOBART, Model: N50G) initially at low speed. Thereafter, it was massaged along with salt, sodium tri polyphosphate and sodium nitrite at medium speed to facilitate the extraction of protein. Subsequently, ice, spice mix, condiments, refined wheat flour and extender blend were added one by one and massaged to prepare a final mix of tacky exudate. Functional restructured spent hen meat blocks were prepared by using blend of different binders and extenders [3 % potato (boiled and mashed), 5 % TSP (1:1 hydration, w/w), 0.4 % WPC (1:1 hydration, w/w), 3 % oat meal (1:1 hydration, w/w) and 7 % barley flour (1:1 hydration, w/w)] after replacing meat in prestandardized restructured spent hen meat blocks formulation. The final mix was weighed, stuffed into aluminium moulds and cooked in steam cooker for 50 min without pressure. Cooked meat blocks were removed from moulds after cooling down to room temperature and cut into uniform slices of 7 mm width with food slicer (Electrolux H 300). Slices were vacuum-packaged in multilayered nylon barrier films using Roschermatic packaging machine (Model VS 19S, Germany) and

Table 1 Formulation of restructured spent hen meat blocks

Ingredients	Control percentage (w/w)	FRSHMB Percentage (w/w)
Spent hen meat	78.4	60.0
Ice	10.0	10.0
Table salt	1.8	1.8
STPP	0.3	0.3
Refined wheat flour (*maida*)	5.0	5.0
Condiments	3.0	3.0
Dry spices	1.5	1.5
Sodium nitrite (ppm)	150	150
Barley flour (1:1 hydration, w/w)	–	7
Texturized soy protein (1:1 hydration, w/w)	–	5
Potato (boiled and mashed)	–	3
Oat meal (1:1 hydration, w/w)	–	3
Whey protein concentrate (1:1 hydration, w/w)	–	0.4

stored at refrigerated temperature (4 ± 1 °C). The stored samples were analysed for 60 days at an interval of 15 days for physico-chemical, microbiological and sensory quality.

Proximate Composition

Moisture, protein, crude fat and ash contents of restructured spent hen meat blocks were determined by standard procedures of Association of Official Chemist [2].

pH

The pH of samples was measured by method of Trout et al. [23]. Ten grams of sample was homogenized with 50 ml of distilled water using Ultra Turrax tissue homogenizer (T-25 Germany) for about a minute. The pH of the meat suspension was measured with digital pH meter (Elico India L1 127) equipped with combined glass electrode.

TBA Value

Thiobarbituric acid (TBA) value of samples during storage was determined by using the distillation method described by Tarladgis et al. [22]. Fifty millilitres of distilled water was added in ten grams of meat sample and homogenized for 2 min in an Ultra Turrax tissue homogenizer (T-25 Germany). The slurry was transferred quantitatively to a 500-ml Kjeldahl flask, which was then rinsed with 45 ml of distilled water, washed and transferred to the flask to which 5 ml of 6 N HCl was added. Few drops of liquid paraffin were added to prevent bumping during heating. The flask was heated to high temperature, and 50 ml distillate was collected in a graduated stopper glass cylinder. The distillate was thoroughly mixed, and 5 ml of distillate was pipetted in duplicate into 20-ml glass stopper test tubes. Five millilitres of TBA reagent was added to each test tube. The contents were mixed well and immersed in boiling water bath for 35 min. A blank consisting of 5 ml of distilled water and 5 ml of TBA reagent was similarly prepared. The tubes were cooled for 10 min under tap water, and optimal density was recorded using spectrophotometer (Beckman DU 640, USA) at 538 nm. Using O.D. was multiplied by the factor 7.8, and TBA value was expressed as mg malonaldehyde/Kg of sample.

Microbiological Quality

Standard plate count (SPC), psychrophilic count (PC), coliform count and anaerobic count in the samples during storage period were determined as per the method described by APHA [3]. Readymade media from Hi-media Laboratories Pvt. Ltd., Mumbai, were used for the enumeration of microbes. Preparation of samples and serial dilutions was done near the flame in a horizontal laminar flow apparatus which was pre-sterilized by ultraviolet irradiation (model: YSI-188, Yarco Sales Pvt. Ltd., New Delhi) observing all possible aseptic precautions. The plates for mesophilic counts were incubated at 37 ± 1 °C for 48 h, and plates showing 30–300 colonies were counted. The plates for psychrotrophic counts were incubated at 4 ± 1 °C for 10–14 days, and colonies were counted. Coliform count was detected using Violet Red Bile Agar (VRBA), and the plates were incubated at 37 ± 1 °C for 48 h. The number of red-purple colonies with about 0.5 mm diameter surrounded by a zone of precipitated bile was counted. Colonies judged to be borderline cases were also counted. The average number of colonies was expressed as $\log_{10}$ cfu/g sample.

Sensory Evaluation

Sensory evaluation was conducted using eight-point descriptive scale [11] for general appearance, flavour, texture, binding, juiciness and overall acceptability, where 8 = excellent; 1 = extremely poor. Samples were evaluated by seven-member experienced sensory panelists, consisted of scientists and postgraduate students of the Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar. The samples were warmed (45 °C) in an oven for 1 min and served to the panellists. Plain water was provided to rinse the mouth between the samples.

Statistical Analysis

The experiment was replicated three times, and the data obtained were analysed statistically for analysis of variance (ANOVA), Duncan's multiple range test, t test and least significance difference test using SPSS 16.0 software package developed as per the procedure of Snedecor and Cochran [20].

Results and Discussion

The mean scores for physico-chemical properties of control and functional restructured spent hen meat blocks are presented in Table 2. Product yield and pH of FRSHMB were significantly higher ($p < 0.05$) as compared to control. Increase in the product yield might be attributed to the gelatinizing property of starch imparted by synergistic action of potato, barley flour and oat meal. Increase in the pH of FRSHMB might be due to the replacement of lean meat with binders and extenders having neutral or slightly higher pH than that of meat. Moisture and fat percentage of FRSHMB were significantly lower ($p < 0.05$) than control. The decrease in moisture and fat percentage might be attributed to less moisture and fat content in hydrated binders/extenders as compared to meat. Ash percentage of FRSHMB was significantly higher ($p < 0.05$) than control. Similar results were reported in restructured chicken meat blocks extended with different combinations of vegetative extenders [17]. Moisture-to-protein ratio of FRSHMB did not differ significantly ($p > 0.05$) from control product. Total dietary fibre content of FRSHMB was significantly higher ($p < 0.05$) than control. It might be due to incorporation of barley flour, oat meal, TSP and potato in the functional product.

Table 2 Physico-chemical properties of the functional restructured spent hen meat blocks (mean ± SE)

Parameters	Treatment	
	Control	FRSHMB
Product yield (%)	$92.17^{b} \pm 0.51$	$95.07^{a} \pm 0.45$
Product pH	$6.24^{b} \pm 0.006$	$6.26^{a} \pm 0.003$
Moisture (%)	$71.63^{a} \pm 0.46$	$68.34^{b} \pm 0.35$
Protein (%)	$18.49^{a} \pm 0.20$	$17.34^{b} \pm 0.39$
Fat (%)	$2.90^{a} \pm 0.03$	$2.15^{b} \pm 0.04$
Ash (%)	$2.91^{b} \pm 0.04$	$3.04^{a} \pm 0.05$
Moisture/protein ratio	3.87 ± 0.04	3.94 ± 0.08
Dietary fibre (%)	$0.49^{b} \pm 0.04$	$4.83^{a} \pm 0.10$

Mean ± SE with different superscripts in a row differ significantly ($p < 0.05$)

n_1 (PY) = 3, n_2 (physico-chemical parameters) = 6

The physico-chemical and microbiological quality of vacuum-packaged control and functional restructured spent hen meat blocks during refrigerated storage (4 ± 1 °C) at regular interval of 15 days is presented in Table 3. There was a gradual decrease in the pH of control as well as functional restructured spent hen meat blocks with increase in storage period, and it decreased significantly ($p < 0.05$) from 30th day of storage and onwards. In general, decrease in pH of vacuum-packaged product during storage might be due to the bacterial degradation of carbohydrates into organic acids leading to decrease in pH. The pH of functional restructured spent hen meat blocks was significantly lower ($p < 0.05$) as compared to control on 45th and 60th days of storage. This might be attributed to the difference in the formulation which could have provided easy carbohydrate substrate for bacterial action on it. The findings are in accordance with those of Khate [12] and Pexara et al. [18], who have also reported decline in pH of vacuum-packaged meat products during refrigeration storage.

TBA values of control and functional restructured spent hen meat blocks showed an increasing trend throughout the storage period. A significant increase ($p < 0.05$) in TBA value of control as well as functional restructured spent hen meat blocks was observed from 30th day onwards. The TBA values of functional restructured spent hen meat blocks were significantly lower ($p < 0.05$) as compared to control on 30th, 45th and 60th days of storage. Lower TBA value of functional restructured spent hen meat blocks might be attributed to the antioxidative properties of dietary fibres. The minimum threshold value of TBA number of cooked meat products during storage was 0.5–1.0 mg as detected by a trained panel [22]. A range of 0.6–2 mg was considered to be the detectable minimum level for off flavour by inexperienced panellists [9]. The TBA values of the vacuum-packaged chicken frankfurters showed an increasing trend during refrigerated storage [10]. Slow rate in increasing TBA value in vacuum-packaged product could be due to the creation of efficient oxygen barrier environment inside the multilayered nylon pouches, thereby inhibiting lipid oxidation to a great extent.

There was a progressive increase in standard plate count (SPC) of both control and functional restructured spent hen meat blocks with increase in the storage period. However, it was well within the maximum permissible limit for cooked meat products up to 45th day of storage. On 60th day of storage, SPC was beyond the permissible level of bacterial count of $\log_{10} 5.33$ cfu/g which is considered to be indicative of unacceptability in cooked meat products [4] in both control and functional restructured spent hen meat blocks. Marginally higher SPC of functional restructured spent hen meat blocks as compared to control could be due to comparatively high concentration of carbohydrate. Slow increase as compared to aerobic packaging could be attributed to lack

Table 3 Physico-chemical and microbiological quality of vacuum-packaged functional restructured spent hen meat blocks during refrigerated storage (4 ± 1 °C)

Treatments	Refrigerated storage period (days)				
	0	15	30	45	60
pH					
Control	$6.24^{aB} \pm 0.01$	$6.23^{a} \pm 0.01$	$6.20^{b} \pm 0.01$	$6.18^{bA} \pm 0.008$	$6.08^{cA} \pm 0.01$
FRSHMB	$6.26^{aA} \pm 0.007$	$6.25^{a} \pm 0.008$	$6.18^{b} \pm 0.025$	$6.16^{bB} \pm 0.01$	$6.04^{cB} \pm 0.01$
TBA value (mg malonaldehyde/Kg)					
Control	$0.26^{c} \pm 0.02$	$0.29^{c} \pm 0.01$	$0.35^{bA} \pm 0.02$	$0.40^{bA} \pm 0.008$	$0.44^{aA} \pm 0.007$
FRSHMB	$0.25^{c} \pm 0.01$	$0.26^{bc} \pm 0.01$	$0.30^{cB} \pm 0.005$	$0.34^{bB} \pm 0.01$	$0.38^{aB} \pm 0.01$
Standard plate count ($\log_{10}$ cfu/gm)					
Control	$1.27^{d} \pm 0.14$	$2.11^{c} \pm 0.24$	$2.68^{c} \pm 0.17$	$3.71^{b} \pm 0.13$	$5.38^{a} \pm 0.25$
FRSHMB	$1.23^{d} \pm 0.12$	$2.15^{d} \pm 0.20$	$2.74^{c} \pm 0.13$	$3.57^{b} \pm 0.19$	$5.42^{a} \pm 0.37$
Psychrophilic count ($\log_{10}$ cfu/gm)					
Control	ND	$1.01^{c} \pm 0.15$	$1.36^{c} \pm 0.13$	$1.87^{b} \pm 0.15$	$2.34^{a} \pm 0.19$
FRSHMB	ND	$1.22^{c} \pm 0.12$	$1.42^{c} \pm 0.15$	$1.89^{b} \pm 0.09$	$2.27^{a} \pm 0.10$
Anaerobic count ($\log_{10}$ cfu/gm)					
Control	ND	ND	$1.28^{c} \pm 0.09$	$2.22^{b} \pm 0.08$	$3.02^{a} \pm 0.12$
FRSHMB	ND	ND	$1.31^{c} \pm 0.05$	$2.12^{b} \pm 0.15$	$3.07^{a} \pm 0.10$
Coliform count ($\log_{10}$ cfu/gm)					
Control	ND	ND	ND	$1.23^{b} \pm 0.12$	$1.77^{a} \pm 0.01$
FRSHMB	ND	ND	ND	$1.35^{b} \pm 0.18$	$1.96^{a} \pm 0.06$

Mean ± SE with different superscripts in a row (small alphabet) and column (capital alphabet) differ significantly ($p < 0.05$)

$n = 6$ for each treatment

of permeability of multilayered nylon pouches to oxygen, carbon dioxide and water vapour putting a check on further growth of microbes. Significant increase in total viable count of restructured poultry and pork patties during refrigerated storage under vacuum packaging was also reported [5, 15].

Psychrophils were observed on 15th day of storage in both control and functional restructured spent hen meat blocks. Thereafter, psychrophilic count increased significantly ($p < 0.05$) on 45th and 60th days of storage in both control and functional restructured spent hen meat blocks. Initial absence could be attributed to retardation of the log phase of bacterial growth due to the reduced metabolic rate. The significant increase in the psychrophilic count on subsequent storage periods might be due to the conducive water activity and physical environment favourable for the growth of bacteria. Anaerobic plate count was detected on 30th day of storage in both control and functional restructured spent hen meat blocks and then increased significantly ($p < 0.05$) at each successive storage interval. A marginally lower anaerobic plate count was observed in control throughout storage period as compared to functional restructured spent hen meat blocks. Increase in anaerobic plate count did not bring about marked effect on the quality of the product up to 45th day of storage. However, on 60th day of storage, higher anaerobic count showed deteriorative effect on the quality of restructured spent hen meat blocks. It might be due to the action of anaerobic bacteria on protein and carbohydrate resulting in production of some off flavour volatiles. The anaerobes and facultative anaerobes play an important role in the spoilage of vacuum-packaged meat [7].

Coliforms were not detected up to 30th day of storage in both control and functional restructured spent hen meat blocks. However, coliforms were detected on 45th day of storage in both control and functional restructured spent hen meat blocks and then increased significantly ($p < 0.05$) on 60th day of storage. The absence of coliforms initially might be attributed to thermal injury of bacterial cells during cooking and the fact that injured bacterial cells generally need some lag phase before active multiplication is initiated. Chilling and the vacuum environment might also have prevented the initial growth of coliforms in vacuum-packaged restructured spent hen meat blocks. Coliforms in vacuum-packaged restructured mutton slices during refrigerated storage were also observed by Reddy et al. [19].

Sensory Quality

Sensory attributes of vacuum-packaged control and functional restructured spent hen meat blocks during

Table 4 Sensory quality of vacuum-packaged functional restructured spent hen meat blocks during refrigerated storage

Treatments	Refrigerated storage period (days)				
	0	15	30	45	60
General appearance					
Control	$7.02^{a} \pm 0.04$	$7.00^{a} \pm 0.06$	$6.89^{a} \pm 0.03$	$6.75^{b} \pm 0.05$	ND
FRSHMB	$7.10^{a} \pm 0.03$	$7.07^{a} \pm 0.06$	$6.96^{a} \pm 0.05$	$6.81^{b} \pm 0.07$	ND
Flavour					
Control	$7.12^{a} \pm 0.05$	$7.05^{ab} \pm 0.06$	$6.94^{b} \pm 0.04$	$6.72^{cA} \pm 0.05$	ND
FRSHMB	$7.04^{a} \pm 0.04$	$6.99^{ab} \pm 0.07$	$6.87^{b} \pm 0.02$	$6.55^{cB} \pm 0.05$	ND
Texture					
Control	$7.10^{a} \pm 0.06$	$7.04^{a} \pm 0.04$	$6.95^{ab} \pm 0.04$	$6.83^{b} \pm 0.05$	ND
FRSHMB	$7.03^{a} \pm 0.05$	$6.96^{a} \pm 0.05$	$6.91^{ab} \pm 0.06$	$6.76^{b} \pm 0.05$	ND
Binding					
Control	$7.04^{a} \pm 0.04$	$7.01^{a} \pm 0.04$	$6.96^{a} \pm 0.05$	$6.80^{b} \pm 0.06$	ND
FRSHMB	$7.11^{a} \pm 0.03$	$7.08^{a} \pm 0.02$	$7.00^{a} \pm 0.03$	$6.84^{b} \pm 0.05$	ND
Juiciness					
Control	$7.10^{a} \pm 0.06$	$7.03^{ab} \pm 0.05$	$6.90^{bc} \pm 0.06$	$6.77^{c} \pm 0.06$	ND
FRSHMB	$7.07^{a} \pm 0.04$	$6.98^{a} \pm 0.06$	$6.79^{b} \pm 0.05$	$6.69^{c} \pm 0.04$	ND
Overall acceptability					
Control	$7.12^{a} \pm 0.08$	$7.06^{a} \pm 0.07$	$6.94^{ab} \pm 0.04$	$6.78^{bA} \pm 0.05$	ND
FRSHMB	$7.07^{a} \pm 0.04$	$7.02^{a} \pm 0.06$	$6.91^{b} \pm 0.04$	$6.65^{cB} \pm 0.04$	ND

Mean ± SE with different superscripts in a row (small alphabet) and column (capital alphabet) differ significantly ($p < 0.05$)

$n = 21$ for each treatment, *ND* not determined

refrigerated storage (4 ± 1 °C) at regular interval of 15 days are given in Table 4. Mean sensory scores for general appearance were not affected significantly up to 30th day of storage in both control and functional restructured spent hen meat blocks. However, scores decreased significantly ($p < 0.05$) on 45th day of storage. Decrease in general appearance scores might be due to pigment breakdown, depletion of nitrite and browning reactions. There are several factors which may influence the appearance of cooked meat such as pH, meat source, packaging conditions, preservation techniques, fat content, and added ingredients. The colour variability with pH was not as pronounced in the cooked product as when in raw form [6].

There was a gradual decrease in flavour scores of control and functional restructured spent hen meat blocks, and it declined significantly ($p < 0.05$) from 30th day of storage and onwards. On 45th day of storage, there was a significant difference ($p < 0.05$) in flavour of control and functional restructured spent hen meat blocks which might be due to difference in the formulation. The decrease in flavour scores with storage period might be due to increased TBA value. Similar results were reported in vacuum-packaged restructured buffalo meat blocks and pork patties during refrigerated storage [14, 15].

Mean sensory scores for texture were not affected significantly up to 30th day of storage either in control or in functional restructured spent hen meat blocks. However, scores decreased significantly ($p < 0.05$) on 45th day of storage, which might be attributed to some breakdown of protein as well as degradation of other non-meat ingredients as a result of increasing bacterial activity. There was no significant difference in binding scores of control or functional restructured spent hen meat blocks up to 30th day of storage. Significant decrease in binding scores was observed in 45th day of storage which might be due to disintegration of protein matrix.

Juiciness scores of control and functional restructured spent hen meat blocks decreased gradually with increase in the storage period, and it decreased significantly ($p < 0.05$) on 30th and 45th days of storage. There was a gradual decrease in overall acceptability scores of control and functional restructured spent hen meat blocks with increase in the storage period and it declined significantly ($p < 0.05$) from 30th day onwards. Decrease in overall acceptability might be attributed to a gradual decrease in other sensory attributes during the storage period. On 45th day of storage, there was a significant difference ($p < 0.05$) between the overall acceptability scores of control and functional restructured spent hen meat blocks. It might be due to perceived difference in the flavour of the products. Significant decrease ($p < 0.05$) in juiciness and overall acceptability was also reported in vacuum-packaged restructured mutton slices during refrigeration storage [19]. Sensory evaluation was not conducted on 60th day of storage due to higher microbial load, off flavour and unacceptability of the products.

Conclusion

The present study revealed that control and functional restructured spent hen meat blocks remained quite acceptable and retained good to very good acceptability in vacuum-packaged multilayered nylon pouches during refrigeration storage (4 ± 1 °C) up to 45 days without any marked loss of physico-chemical, microbiological and sensory quality. Hence, it can be concluded that functional restructured spent hen meat blocks could be stored safely in vacuum packaging for 45 days at refrigeration temperature (4 ± 1 °C).

Acknowledgments The authors are highly thankful to the Director, Indian Veterinary Research Institute, Izatnagar, for providing the required facilities to carry out the research work. The financial assistance provided by Indian Council of Agricultural Research, New Delhi, in the form of Senior Research Fellowship to corresponding author for Ph.D. is gratefully acknowledged.

References

1. Abe S, Hirata A, Kimura T, Yamuchi K (1996) Effects of collagen on toughness of meat from spent laying hens. J Jpn Soc Food Sci Technol 43:831–834
2. AOAC (1995) Official method of analysis, 16th edn. Association of Official Analytical Chemists, Washington, DC
3. APHA (1984) Compendium of method for microbiological examination of food. In: Speck ML (ed) Compendium of methods for microbiological examiination of foods, 2nd edn. American Public Health Association, Washington, DC
4. Cofrades S, López-López I, Ruiz-Capillas C, Triki M, Jiménez CF (2011) Quality characteristics of low-salt restructured poultry with microbial transglutaminase and seaweed. Meat Sci 87:373–380
5. Cremer ML, Chipley JR (1977) Satellite food service system: time and temperature and microbiological and sensory quality of precooked frozen hamburger patties. J Food Prot 40:603–607
6. Fletcher DL, Qiao M, Smith DP (2000) The relationship of raw broiler breast meat color and pH to cooked meat color and pH. Poult Sci 79:784–788
7. Fu AH, Molins RA, Sebranek JG (1992) Storage quality characteristics of beef rib eye steaks packaged in modified atmospheres. J Food Sci 57(283–287):301
8. Genigeorgis C (1985) Microbial and safety implications of the use of modified atmospheres to extend thestorage life of fresh meat and fish. Inter J Food Microbiol 1:237–251
9. Greene BA, Cumuze TH (1982) Relationship between TBA numbers and inexperienced panelists. Assessments of oxidized flavour in cooked beef. J Food Sci 47:52–58
10. Lin KW, Lin SN (2002) Physicochemical properties and microbial stability of reduced-fat Chinese-style sausage stored under modified atmosphere systems. J Food Sci 67:3184–3189
11. Keeton JT (1983) Effect of fat and sodium chloride salt/phosphate levels on the chemical and sensory properties of pork patties. J Food Sci 48:878–881
12. Khate K (2007) Development of designer pork sausage with low salt and fat. Ph.D. thesis, Indian Veterinary Research Institute, India
13. Kondiah N (2010) Challenges and issues for development in Processed Meat Sector. Training manual on Requirements and developments in processed meat sector for better utilization of meat animal resources. National Research Center on Meat, Hyderabad, pp 1–6
14. Kumar S (2002) Effect of milk proteins on the quality of restructured buffalo meat blocks. Dissertation, Indian Veterinary Research Institute
15. Kumar M, Sharma BD (2004) Efficacy of barley flour as fat substitute on processing quality and storage stability of low-fat ground pork patties. J Food Sci Technol 41:496–502
16. Macedo MLH, Barancelli GV, Castillo CJC (2011) Microbial deterioration of vacuum-packaged chilled beef cuts and techniques for microbiota detection and characterization: a review. Brazilian J Microbiol 42:1–11
17. Malav OP, Sharma BD, Talukder S, Mendiratta SK, Kumar RR (2015) Quality characteristics and storage stability of restructured chicken meat blocks extended with different combinations of vegetative extenders. J Food Sci Technol 52:391–398
18. Pexara ES, Metaxopoulos J, Drosinos EH (2002) Evaluation of shelf life of cured, cooked, sliced turkey fillets and cooked pork sausages—'piroski'—stored under vacuum and modified atmospheres at +4 and +10 °C. Meat Sci 62:33–43
19. Reddy GVB, Sen AR, Nair PN, Reddy KS, Reddy KK, Kondaiah N (2013) Effects of grape seed extract on the oxidative and microbial stability of restructured mutton slices. Meat Sci 95:288–294
20. Snedecor GW, Cochran WG (1995) Statistical methods, 8th edn. IOWA State University Press, Ames
21. Stiebing A (1985) Frankfurter type sausage: heat treatment and shelf life. Fleischwirtschaft 65:1087–1091
22. Tarladgis BG, Watts BM, Yaunathan MT, Dugan LR (1960) A distillation method for the quantitative determination of malonaldehyde in rancid foods. J Am Oil Chem Soc 37:66–71
23. Trout ES, Hunt MC, Johnson DE, Claus JR, Kastner CL, Kropf DH (1992) Characteristics of low fat ground beef containing texture modifying ingredients. J Food Sci 57:19–24
24. Zhang W, Xiao S, Samaraweera H, Lee EJ, Ahn DU (2010) Improving functional value of meat products. Meat Sci 86:15–31