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ORIGINAL ARTICLE

Effect of skin, enrobing and refrigerated storage on the quality characteristics of chicken meat balls

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Abstract The study was conducted to evaluate the utilization of skin in the preparation of meat balls. The meat balls were prepared by incorporating skin at different levels viz. 25%, 50%, 75% and 100% replacing lean meat in the formulation. The meat balls were further enrobed to see the effect of coating on the quality characteristics of meat balls. Parameters namely emulsion stability, cooking yield, proximate composition and sensory parameters of meat balls decreased significantly ($P<0.05$) with the increasing skin level. Based on various sensory parameters, meat balls containing 50% skin were optimized as best among coated as well as non-coated meat balls. Both coated as well as control meat balls were aerobically packaged in low density polyethylene (LDPE) pouches and were analyzed at a regular interval of 0, 7 and 14 days for various quality parameters during refrigerated storage at 4±1°C. TBARS value, total plate count and psychrophilic count increased significantly ($P<0.05$) whereas the scores for various sensory attributes decreased significantly ($P<0.05$) during storage. Coliforms were not detected throughout the period of storage. Thus, meat balls utilizing chicken skin were stored for a period of 14 days at refrigerated temperature (4±1°C) with changes in the quality parameters under acceptable limits.

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Introduction

Poultry industry, a vibrant, organized and scientific sector now days, can play a key role in ensuring quality animal proteins at cheaper rate particularly through culled and spent hen meat. Processing of meat from spent hen to different value added products open the avenues for not only its judicious utilization but a readily accessible animal protein sources for poor. Emphasis over food processing and economic formulation has made it necessary to do the needful work in this direction.

With increasing poultry production and centralized processing, availability of chicken byproducts has also necessitated their profitable disposal. Skin constitutes approximately 12.10% of the carcass weight in *Vanaraja* males and 12.76% of the carcass weight of *Vanaraja* females of over 80 weeks of age (Pathak et al. 2009). Skin is one of the poultry byproducts that are not utilized under the Indian conditions as most of the unorganized poultry processing units remove feathers along with skin which is considered as waste. This causes monetary and nutritional losses to the poultry processors and consumers, respectively. Some reports are available regarding use of skin, gizzard and heart (SGH) to the extent of 10% in preparing chicken sausages. Antipova and Polianski (1996) tried to utilize abattoir poultry wastes in processing meat loaf. Baker and Darfler (1967) evaluated the substitution of chicken skin for meat and fat and observed that, as the amount of skin in the formula was increased, the frankfurters became tougher. To obtain a desirable firm texture in chicken frankfurters the addition of 15% skin normally present in the boned-out chicken was suggested (Baker et al. 1968).

However, very little information is available regarding the use of chicken skin in the preparation of convenient meat products. There is a need to develop certain skin based meat products particularly that can incorporate higher levels of skin without much compromise in the sensory parameters. Furthermore, some reports indicate the use of skin in meat products as least desirable tissue on the basis of functional (Kondaiah and Panda 1987) and emulsification properties (Hudspeth and May 1969) among the low value components. Thus, in order to improve the eating quality of meat products containing higher levels of skin, further processing and value addition are essential. Hence, in this study, a convenient processed meat product, chicken meat ball was further enrobed.

Coating/enrobing of meat products is a method of value addition that enhances the acceptability of meat products. Enrobing adds numerous advantages to meat products such as value addition, versatility to consumers and improvement of nutritive value as well as eating and microbial qualities of the products (Richardson 1989). Edible coatings and films generally can be defined as thin layers of edible materials applied on or even within foods by immersing, brushing, spraying or wrapping, in order to offer a selective barrier against the transmission of gases, vapors and solutes while also offering mechanical protection. It improves the texture of the product, remarkably reducing the product cost, making it an avenue for value addition, better consumer acceptability, preserving the nutritive value, reducing moisture and weight loss, and improving juiciness, flavour and tenderness (Eyas Ahamed et al. 2007; Mandava and Hoogen Kamp 1999; Biswas et al. 2004). Whole egg liquid contains high protein and fat, has sufficient water quantity and is viscous in consistency, which are essential qualities of a good batter (Eyas Ahmed et al. 2007). By retarding fat oxidation and moisture loss from the meat products, enrobing improves the shelf life of meat products. It further lessens oil absorption by reducing water loss during frying.

Keeping all these factors in consideration, present study was envisaged to explore the utilization of the skin in the development of chicken meat balls with an aim to incorporate higher level of skin in the formulation without adversely affecting the sensory attributes and to evaluate the effect of enrobing on the developed product.

Material and methods

Source of chicken meat and skin

Vanaraja birds (irrespective of sex) of the age group of over 80 weeks were purchased from State Animal Husbandry Department. The birds were slaughtered using ritual Halal method. The body fat was trimmed and deboning of dressed chicken was done manually removing all tendons and separable connective tissue. The skin was also manually removed from the chicken carcasses. Both lean meat as well as skin were packed in polythene bags separately and frozen at –20°C overnight and used.

Fat

Refined cottonseed oil of brand name '*Ginni*' was purchased from local market and used. It approximately contained 900 k. cal of energy, 0 g of carbohydrate, 0 g of proteins, 0 g of cholesterol, 24 g of saturated fatty acids, 54 g of mono-unsaturated fatty acids and 0 g of trans-fatty acids per 100 g.

Spice mixture

The spice mix formula used for preparation of the meat balls contained anise (*Pimpinalla anisum*, *soanf*-13%), Bay leaves (*Laurus nobilis, tej patta*-2%), Black pepper (*Piper nigrum*, *kali mirch*-5%), green cardamom (*Elettaria cardamomum,* choti elaichi-5%), Cinnamon (*Cinnamomum zeylanicum, dalchini*-6%), Cloves (*Syzygium aromaticum, laung*-2%), Dry fenugreek powder (*Foenum-graecum, meathi*-6%), Coriander (*Coriandrum sativum, dhania*-20%), Cumin seed (*Cuminum cyminum, jeera*-12%), Mace (*Myristica fragrans, javitri*-2%), Nutmeg (*Myristica fragrans, jaiphal*-2%), Red chilli (*Capsicum frutescens, lal mirch*-12%), Black cardamom (*Amomum subulatum, badi elaichi*-5%), Mint leaves (*Lamiaceae*, *pudina*-3%) and Dry ginger powder (Zingiber *officinale*, *saunth*-5%). The spices were purchased from local market. After removal of extraneous matter, all spices were dried in an oven at 50°C for overnight and then ground in grinder to powder. The coarse particles were removed using a sieve (100 mesh) and the fine powdered spices were mixed in required proportion to obtain spice mixture for meat balls. The spice mixture was stored in plastic airtight container for subsequent use.

Methodology of preparation of balls from meat of spent hen

The different ingredients used for the preparation of the meat balls were lean meat (52.60%), gram paste (10%), crushed ice (5%), egg (5%), vegetable oil (10%), condiment mixture (5%), refined wheat flour (4%), spice mixture (2%), table salt (1.5%), monosodium glutamate (0.5%), sodium tripolyphosphate (0.4%), Sodium nitrite (120 ppm) and whole milk powder (4%). Condiments were prepared by making a fine paste of onion, garlic and ginger in the ratio of 3:2:1. Gram paste was prepared by soaking split skinless Bengal gram over night in equal amount of water (1:1 *w/w*) in refrigerator and converted to paste in grinder.

Lean meat from spent hen was cut into smaller chunks and minced in a Sirman mincer (MOD-TC 32 R10 U.P. INOX, Marsango, Italy) with 6 mm plate twice. Skin was also minced three times with 6 mm plate. The common salt, vegetable oil, refined wheat flour (maida), nitrite, spice mixture and condiment mixture were added to weighed meat according to formulation. Meat emulsion for chicken meat balls was prepared in Sirman Bowl Chopper [MOD C 15 2.8 G 4.0 HP, Marsango, Italy]. Minced meat was mixed and blended with salt, water and nitrite for 1 min followed by addition of required amount of refined vegetable oil and blending for another 30 s. This was followed by addition of binders chopping for 30 s, addition of spice mixture, condiments and chopping for another 30 s to get the desired emulsion. Adequate care was taken to keep the end point temperature below 18°C by addition of meat and other ingredients in chilled/partially thawed form and by addition of crushed ice. Aliquots of raw emulsions from various treatments under each trial of an experiment were collected in plastic bottles for analysis. Each ball was prepared from 20 g emulsion. The molded raw balls were deep fat fried for a total time of about 5 min.

Method of coating

The batter for coating the balls was prepared by mixing gram flour (*besan*) in water in the ratio of 2.2:1. Balls of approximately 20 g in weight were first dipped in egg albumen liquid followed by rolling in corn flour. Balls were then dipped in batter, removed and deep fat fried.

The coated meat balls along with uncoated cooked control meat balls were packaged in low density polyethylene pouches and stored at refrigeration temperature (4±1°C). The products were analyzed for physicochemical, sensory and microbiological qualities at a regular interval of 0, 7 and 14 days.

Analytical procedures

The pH of raw mix/emulsion soon after its preparation and of cooked meat balls was determined by the method of Keller et al. (1974) using a digital meter (Systronics Digital pH Meter 803, serial No. 603).

The moisture, crude protein, ether extract and ash content of chicken meat balls both raw and cooked were determined by standard methods using hot air oven, Kjeldhal assembly and Soxhlet extraction apparatus respectively (AOAC 1995).

Emulsion stability

Emulsion stability of meat emulsion was determined as per procedure described by Townsend et al. (1968) with some modifications. About 25 g of samples were placed in polyethylene bags (Size 12×10 cm). Bags with samples were weighed and sealed. These bags were immersed in a thermostatically controlled water bath at 80°C for 20 min, the bags removed from the water bath, cut open and cook fluids (fat, water and solids) drained. The cooked samples were weighed. Loss of weight after cooking was calculated and expressed (in percentage) as an index of ES.

Microbiological examination

Microbiological profile viz. total plate count, psychrophilic count and coliform count in the samples were determined by methods described by APHA (1984). Readymade media (Hi-Media) were used for the analysis. Ten grams of sample was taken in a presterilized pestle and mortar mixed properly with 90 mL of 0.1% sterile peptone water. Serial 10-fold dilutions were made with peptone water (0.1%). Preparation of sample and serial dilutions were done near a flame in a laminar flow apparatus (Thermo Electron Corporation. D-63505 Langenselbold, Robert Boschstr. 1, Germany.) observing all possible aseptic conditions.

Total plate count

Twenty-three and half grams of plate count agar was suspended in 1000 mL of distilled water followed by boiling to dissolve the media completely and sterilization by autoclaving at 15 lbs of pressure (121 °C) for 15 min. About 20 mL of the sterilized medium was used for each sterile petri dish and pour plate technique was used for determining the total aerobic mesophilic count in sample. Plates were incubated at 35 °C for 48 h. Colonies were counted using an electronic colony counter. The average number of colonies were multiplied by the reciprocal of the dilution and expressed as $\log_{10}$ colony forming units (cfu)/g of sample.

Psychrophilic count

The plates were prepared similar to that of aerobic mesophiles count but incubated at 8±2 °C for 10 days. The colonies were counted and expressed as $\log_{10}$cfu/g.

Coliform count

41.5 g of Violet Red Bile Agar obtained from Hi-Media Laboratories Pvt. Ltd., Mumbai (code No.M091) was suspended in one litre of distilled water, boiled to dissolve the medium completely and cooled to 45°C. The final pH was adjusted to 7.4±0.2 at 25°C. Pour plate with overlay techniques was followed for inoculation of suitable sample dilution and the plates were incubated at 35°±2°C for 24 h. The colonies were counted and results were expressed as $\log_{10}$ cfu/g of sample.

Thiobarbituric acid reacting substances value

Thiobarbituric acid reacting substances value of meat balls during storage was determined using the methods described by Witte et al. (1970). Twenty grams of the sample was homogenized with 50 mL of precooled 20% trichloroacetic acid (TCA) solution. The contents were then transferred quantitatively to a beaker by rinsing with 50 mL of cold distilled water, mixed and filtered through a Whatman No.42 paper. Three milliliters of TCA extract was mixed with 3 mL of thiobarbituric acid (TBA) reagent (0.1 g of 2-thiobarbituric acid dissolved in 100 mL of distilled water) in a test tube and placed in a boiling water bath for 35 min after covering the tube with an inverted small glass beaker of 25-mL capacity. The contents in the tube were cooled under running tap water, and absorbance measured at 532 nm. A blank using 3 mL of precooled 10% TCA solution instead of TCA extract of the sample was also prepared in a similar manner as described above. TBARS value was calculated as mg malonaldehyde per kg of sample by referring to a standard graph (Witte et al. 1970).

Cooking yield

The weight of each ball was recorded before and after cooking. The cooking yield was calculated and expressed as percentage by a formula:

$$\text{Cooking yield percent} = \frac{\text{Weight of cooked balls}}{\text{Weight of raw balls}} \times 100$$

Sensory evaluation

The sensory evaluation of the product was carried for various attributes namely appearance, flavour, juiciness, texture and overall palatability by a panel of seven trained members composed of scientists and research scholars of the Division based on a 8-point hedonic scale, wherein 8 denoted “extremely desirable” and 1 denoted “extremely undesirable” (Seman et al. 1987). The panels were trained for four basic tests, i.e., recognition and threshold test and hedonic tests routinely performed in sensory evaluation laboratory of the Division. Panelists were seated in a room free of noise and odours and suitably illuminated. Coded samples for sensory evaluation were prepared and served warm to panelists at 40 °C. Water was provided for oral rinsing between the samples.

Statistical analysis

Means and standard errors were calculated for different parameters. The data obtained were subjected to statistical analysis (Snedecor and Cochran 1980) for analysis of variance, critical difference and Duncan’s multiple range tests for comparing the means to find the effects between treatments and storage periods for various parameters. In significant effects, least significant differences were calculated at appropriate level of significance (0.05) for a pair wise comparison of treatment means.

Results and discussion

The mean values of various parameters namely pH, emulsion stability and proximate composition of raw meat balls containing 0, 25, 50, 75 and 100% levels of skin are presented in Table 1.

pH and emulsion stability of raw chicken meat balls

A significant ($P<0.05$) influence on emulsion stability was recorded. The mean pH values of the control and treatments were comparable to each other. The mean values of emulsion stability showed a significantly ($P<0.05$) decreasing trend in an alternate fashion with increasing levels of skin. Decreasing trend of emulsion stability may be attributed to the poor functional properties of skin due to its high collagen content. Maurer and Baker (1966) suggested that collagen can be detrimental to the process of making poultry meat emulsions because of the inability of collagen to dissolve and form stabilizing membranes. Similar trend was also observed by Arun et al. (2010) in low fat chicken nuggets.

Proximate composition of raw chicken meat balls

The mean values of various proximate parameters namely moisture percent, crude protein percent and ether extract percent except ash content showed a significantly ($P<0.05$) decreasing trend with increasing levels of skin. However, the mean ash values of emulsion were comparable to each other. Similar findings were reported by Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) in extended chicken patties and chicken *seekh kababs,* respectively who also reported a decrease in moisture percent, protein percent and ether extract percent with increasing level of extension with pressed rice flour, barley flour and porridge, respectively. These decreasing trends in various proximate parameters may be attributed to less moisture; crude protein and ether extract content in skin than that of lean meat in *Vanaraja* chicken.

pH and cooking yield of cooked chicken meat balls

The mean values of various parameters namely pH, cooking yield and proximate composition of cooked chicken meat balls containing 0, 25, 50, 75 and 100% levels of skin are presented in Table 1. The mean pH values of the control and treatments were comparable. It

Table 1 Physicochemical properties of raw and cooked chicken meat balls

Parameters	Level of skin incorporated (%)				
	0	25	50	75	100
Raw Chicken Meat Balls					
pH	6.1±0.02	6.1±0.03	6.1±0.02	6.1±0.03	6.1±0.03
Emulsion stability (%)	86.6^{a}±0.29	85.4^{ab}±0.22	83.8^{bc}±0.66	82.4^{cd}±0.99	81.1^{d}±0.54
Moisture (%)	63.3^{a}±0.52	62.1^{ab}±0.52	60.8^{bc}±0.46	60.6^{c}±0.45	59.9^{c}±0.51
Protein (%)	15.5^{a}±0.36	14.9^{ab}±0.38	14.2^{b}±0.35	14.0^{b}±0.32	13.8^{b}±0.32
Fat (%)	13.6^{a}±0.18	13.3^{a}±0.16	12.6^{b}±0.21	12.2^{bc}±0.16	11.9^{c}±0.10
Ash (%)	2.2±0.01	2.2±0.03	2.1±0.04	2.1±0.02	2.2±0.02
Cooked Chicken Meat Balls					
pH	6.2±0.01	6.2±0.03	6.2±0.02	6.2±0.03	6.2±0.03
Cooking yield (%)	95.2^{a}±0.26	93.0^{b}±0.37	90.5^{c}±0.40	85.9^{d}±0.79	79.5^{d}±1.20
Moisture (%)	63.3^{a}±0.78	62.15^{ab}±0.43	61.91^{b}±0.40	61.75^{b}±0.63	61.75^{b}±0.63
Protein (%)	18.6^{a}±0.31	17.9^{ab}±0.26	17.3^{bc}±0.20	16.7^{cd}±0.14	16.5^{d}±0.19
Fat (%)	15.8^{a}±0.33	15.0^{ab}±0.40	14.7^{ab}±0.31	14.3^{b}±0.30	14.2^{b}±0.35
Ash (%)	2.9^{a}±0.04	2.8^{a}±0.10	2.8^{a}±0.02	2.6^{b}±0.04	2.3^{c}±0.07
Coating Thickness (mm)	2.55±0.09	2.82±0.12	2.95±0.19	2.87±0.19	3.10±0.22

Mean ± SE with different superscripts in a row differs significantly ($P<0.05$), $n=6$ for each treatment

may be due to similar pH of meat and skin. The mean values of cooking yield showed a significantly ($P<0.05$) decreasing trend with increasing levels of skin. Decreasing trend of cooking yield may be attributed to the poor functional properties of skin due to its high collagen content. A similar decrease in cooking yield was also observed by Arun et al. (2010) in low fat chicken nuggets containing apple pulp.

Proximate composition and coating thickness of cooked chicken meat balls

The mean values of various proximate parameters namely moisture percent, crude protein percent, ether extract percent and ash percent showed a significantly ($P<0.05$) decreasing trend with increasing levels of skin. Similar findings were reported by Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) in chicken patties and chicken *seekh kababs* extended by pressed rice flour, barley flour and porridge, respectively. The mean values of the coating thickness (mm), measured by using a Vernier caliper, showed a non-significantly ($P>0.05$) increasing trend from control to the balls containing 100% skin. It may be attributed to the fact that with increasing skin percentage the surface of meat balls became rough and thereby holding more coating material in comparison to smoother surface of control meat balls.

Sensory parameters of cooked chicken meat balls

The mean sensory scores of cooked chicken meat balls with and without coating containing varying levels of skin are presented in Table 2. A significant ($P<0.05$) influence was observed on appearance, flavour, juiciness, texture and overall palatability of uncoated chicken meat balls as a result of incorporation of skin in the formulation whereas a significant ($P<0.05$) influence was observed on flavour, juiciness, texture and overall palatability of coated meat balls. Appearance scores showed a gradual decline but were comparable ($P>0.05$) to control at all levels in case of coated meat balls whereas mean appearance scores of uncoated meat balls decreased significantly ($P<0.05$) with increasing skin levels. Zyl and Zayas (1996), Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) reported similar results with increasing levels of extender in various meat products. Juiciness scores also showed a significant ($P<0.05$) decreasing trend with increasing skin level in the formulation in both coated as well as uncoated meat balls however, juiciness of the meat balls containing 50% skin in their formulation was non-significantly ($P>0.05$) lower than control. Decreasing trend of juiciness may be attributed to the poor functional properties of skin due to its high collagen content. Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) observed similar results with increasing levels of extender in various meat products. The flavour and texture scores also showed a significantly ($P<0.05$) declining trend. Flavour score deceased as a result of dilution of meaty flavour with increase in skin level. Similar decline in flavour score with increasing level of extension was also reported by Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) in the flavour scores of extended chicken patties and extended chicken *seekh kababs* respectively. The decrease in texture scores at

Table 2 Sensory quality attributes of cooked chicken meat balls without and with coating

Sensory attributes	Level of skin incorporated (%)				
	0	25	50	75	100
Without Coating					
Appearance	$7.1^{a}\pm0.12$	$7.0^{a}\pm0.10$	$6.8^{a}\pm0.15$	$6.3^{b}\pm0.14$	$6.2^{b}\pm0.14$
Flavour	$6.9^{a}\pm0.10$	$6.8^{a}\pm0.09$	$6.6^{ab}\pm0.10$	$6.4^{bc}\pm0.10$	$6.2^{c}\pm0.13$
Juiciness	$7.0^{a}\pm0.09$	$6.8^{a}\pm0.09$	$6.7^{ab}\pm0.11$	$6.4^{b}\pm0.14$	$6.0^{c}\pm0.14$
Texture	$7.0^{a}\pm0.10$	$6.9^{ab}\pm0.09$	$6.6^{ab}\pm0.12$	$6.5^{b}\pm0.16$	$6.4^{b}\pm0.16$
Overall palatability	$7.1^{a}\pm0.10$	$6.9^{a}\pm0.09$	$6.6^{ab}\pm0.12$	$6.5^{b}\pm0.12$	$6.4^{b}\pm0.13$
With Coating					
Appearance	7.0 ± 0.11	6.9 ± 0.08	6.8 ± 0.13	6.8 ± 0.06	6.8 ± 0.05
Flavour	$7.0^{a}\pm0.09$	$6.9^{a}\pm0.09$	$6.8^{ab}\pm0.11$	$6.5^{b}\pm0.13$	$6.2^{c}\pm0.15$
Juiciness	$7.1^{a}\pm0.09$	$6.9^{a}\pm0.09$	$6.8^{ab}\pm0.12$	$6.5^{b}\pm0.13$	$6.2^{c}\pm0.15$
Texture	$7.1^{a}\pm0.09$	$6.9^{ab}\pm0.09$	$6.8^{ab}\pm0.13$	$6.6^{bc}\pm0.12$	$6.4^{c}\pm0.14$
Overall palatability	$7.0^{a}\pm0.10$	$6.9^{a}\pm0.09$	$6.7^{ab}\pm0.11$	$6.5^{b}\pm0.11$	$6.4^{b}\pm0.13$

Mean ± SE with different superscripts in a row differs significantly ($P<0.05$). Mean values are scores on 8 point descriptive scale where 1- extremely poor and 8- extremely desirable, $n=21$ for each treatment

higher levels of skin may be due to replacement of structural meat proteins by skin. Such a decline in texture was also supported by findings of Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) in various extended meat products. Overall palatability of product also decreased significantly ($P<0.05$) with increasing skin levels. Such a trend in overall palatability was reflective of change in scores of flavour, juiciness and texture with increased skin levels in the formulation. Similar findings were reported by Nag et al. (1998), Kumar and Sharma (2005, 2006) and Bhat and Pathak (2009) in various extended meat products.

The sensory scores of meat balls for all attributes at 50% skin level were comparable to control. Hence, 50% skin replacement was taken as optimum level in the formulation of both coated as well as uncoated chicken meat balls.

Storage studies

Both coated as well as uncoated meat balls containing 50% skin along with control meat balls were packed in LDPE pouches and stored in refrigerated conditions (4±1°C) for 14 days. Both were analyzed at a regular interval of 0, 7 and 14 days for various physico-chemical, microbiological and sensory properties during refrigerated storage at 4±1°C.

Physicochemical characters

The mean values of various physico-chemical characteristics of aerobically packaged cooked chicken meat balls containing 50% skin and control meat balls are presented in Table 3.

pH

In the present study, refrigerated storage had a significant ($P<0.05$) effect on the pH values of treatments as well as control samples. The effect of storage was obvious as the pH of chicken meat balls followed an increasing trend at progressive storage intervals. The mean pH values of treatment samples were comparable with the mean pH values of control on all days of storage. The increase in pH might be due to accumulation of metabolites of bacterial action on meat and meat products and deamination of meat proteins (Bachhil 1982; Jay 1986). Similar increase in pH was also reported by Nag et al. (1998) in chicken nuggets, Kumar and Sharma (2004) in chicken patties, Chidanandaiah et al. (2009) in buffalo meat patties, Sureshkumar et al. (2010) in buffalo meat sausages, Kumar and Tanwar (2010) in chicken nuggets and Bhat et al. (2010) in chevon *Harrisa*.

Thiobarbituric acid (TBARS) reacting substances value (mg malonaldehyde/kg)

Thiobarbituric acid reacting substances (TBARS) value followed a significant ($P<0.05$) increasing trend from day 0 to 14 in treatment samples as well as control meat balls. A difference among the coated and uncoated meat balls also existed as the TBARS values of coated meat balls were significantly ($P<0.05$) lower then uncoated meat balls on all days of storage except on day 0 when the values of the two were comparable. Coatings are often good oxygen barriers (Conca and Yang 1993) and can retard lipid oxidation in foods (Kester and Fennema 1986). Similar results were reported by Conca and Yang (1993), Kester and Fennema (1986), Krochta et al. (1994) and Earle and McKee (1985) and Chidanandiah et al. (2009) in various

Table 3 Effect of refrigerated storage on quality characteristics of aerobically packaged cooked chicken meat balls

Treatments	Storage period (days)		
	0	7	14
Physico-Chemical Parameters (n_1 (pH) = 3, n_2 (TBARS) = 6 for each treatment)			
pH			
C (0%)	6.2 ± 0.02^{A}	6.3 ± 0.01^{B}	6.3 ± 0.01^{B}
CC (0%)	6.1 ± 0.01^{A}	6.2 ± 0.01^{B}	6.3 ± 0.01^{C}
SK (50%)	6.2 ± 0.02^{A}	6.3 ± 0.01^{B}	6.3 ± 0.01^{B}
SKC (50%)	6.1 ± 0.01^{A}	6.2 ± 0.01^{B}	6.3 ± 0.01^{C}
TBARS (mg malonaldehyde/Kg.)			
C (0%)	0.32 ± 0.02^{Aa}	0.44 ± 0.01^{Ba}	0.60 ± 0.02^{Ca}
CC (0%)	0.33 ± 0.02^{Aa}	0.36 ± 0.01^{Ab}	0.49 ± 0.02^{Bb}
SK (50%)	0.31 ± 0.01^{Aa}	0.43 ± 0.01^{Ba}	0.59 ± 0.02^{Ca}
SKC (50%)	0.31 ± 0.01^{Aa}	0.35 ± 0.01^{Ab}	0.47 ± 0.02^{Bb}
Microbiological Characteristics (*n*=6 for each treatment)			
Total plate count (log cfu/g)			
C (0%)	1.4 ± 0.07^{Aa}	1.9 ± 0.04^{Ba}	2.4 ± 0.01^{Ca}
CC (0%)	1.4 ± 0.08^{Aa}	1.9 ± 0.04^{Bab}	2.4 ± 0.01^{Ca}
SK (50%)	1.6 ± 0.06^{Aa}	2.0 ± 0.03^{Bab}	2.5 ± 0.02^{Cb}
SKC (50%)	1.6 ± 0.05^{Aa}	2.0 ± 0.03^{Bb}	2.5 ± 0.02^{Cb}
Psychrophilic count (log cfu/g)			
C (0%)	Not detected	1.4 ± 0.06^{A}	1.8 ± 0.06^{B}
CC (0%)	Not detected	1.3 ± 0.04^{A}	1.8 ± 0.05^{B}
SK (50%)	Not detected	1.4 ± 0.05^{A}	1.8 ± 0.04^{B}
SKC (50%)	Not detected	1.4 ± 0.08^{A}	1.8 ± 0.06^{B}
Sensory Attributes (*n*=21 for each treatment)			
Appearance			
C (0%)	$7.0^{Aa} \pm 0.11$	$6.8^{ABa} \pm 0.10$	$6.7^{Ba} \pm 0.10$
CC (0%)	$7.1^{Aa} \pm 0.12$	$6.8^{ABa} \pm 0.10$	$6.7^{Ba} \pm 0.10$
SK (50%)	$6.9^{Aa} \pm 0.10$	$6.5^{Bb} \pm 0.10$	$6.4^{Bb} \pm 0.11$
SKC (50%)	$7.0^{Aa} \pm 0.11$	$6.7^{Bab} \pm 0.10$	$6.6^{Ba} \pm 0.11$
Flavour			
C (0%)	$7.1^{Aa} \pm 0.12$	$6.8^{ABa} \pm 0.10$	$6.7^{Ba} \pm 0.10$
CC (0%)	$7.1^{Aa} \pm 0.12$	$6.7^{Aa} \pm 0.11$	$6.6^{Aa} \pm 0.11$
SK (50%)	$6.7^{Aa} \pm 0.11$	$6.4^{Bb} \pm 0.10$	$6.3^{Bb} \pm 0.10$
SKC (50%)	$6.9^{Aa} \pm 0.13$	$6.6^{Aab} \pm 0.11$	$6.6^{Aa} \pm 0.11$
Juiciness			
C (0%)	$7.0^{Aa} \pm 0.11$	$6.7^{Bab} \pm 0.11$	$6.6^{Bab} \pm 0.10$
CC (0%)	$7.1^{Aa} \pm 0.09$	$6.8^{Ba} \pm 0.11$	$6.7^{Ba} \pm 0.11$
SK (50%)	$6.8^{Aa} \pm 0.09$	$6.4^{Bb} \pm 0.10$	$6.3^{Bb} \pm 0.10$
SKC (50%)	$6.9^{Aa} \pm 0.10$	$6.6^{Aab} \pm 0.11$	$6.6^{Aab} \pm 0.11$
Texture			
C (0%)	$7.1^{A} \pm 0.09$	$6.7^{B} \pm 0.11$	$6.6^{B} \pm 0.09$
CC (0%)	$7.0^{A} \pm 0.09$	$6.6^{B} \pm 0.11$	$6.6^{B} \pm 0.09$
SK (50%)	$6.8^{A} \pm 0.09$	$6.4^{B} \pm 0.12$	$6.3^{B} \pm 0.11$
SKC (50%)	$6.9^{A} \pm 0.09$	$6.6^{AB} \pm 0.12$	$6.5^{B} \pm 0.11$
Overall palatability			
C (0%)	$7.0^{A} \pm 0.11$	$6.8^{AB} \pm 0.10$	$6.6^{B} \pm 0.12$
CC (0%)	$7.0^{A} \pm 0.11$	$6.8^{AB} \pm 0.11$	$6.6^{B} \pm 0.12$
SK (50%)	$6.8^{A} \pm 0.11$	$6.7^{AB} \pm 0.10$	$6.5^{B} \pm 0.10$
SKC (50%)	$6.9^{A} \pm 0.10$	$6.8^{AB} \pm 0.09$	$6.6^{B} \pm 0.10$

Mean ± SE with different superscripts in a row wise (upper case alphabet) and column wise (lower case alphabet) differ significantly ($P<0.05$)

coated meat products. A comparatively slow increase in TBARS value of coated meat balls may further be due to lower ether extract percent. The increase in TBARS values on storage might be attributed to oxygen permeability of packaging material (Brewer et al. 1992) that led to lipid oxidation. Dushyanthan et al. (2000), Kumar and Sharma (2004), Chidanandiah et al. (2009), Modi et al. (2009), Kumar and Tanwar (2010), Sudheer et al. (2010) and Bhat et al. (2010) who also found a similar increase in TBARS values upon storage of different meat products.

Microbiological characters

The mean values of various microbiological characteristics of aerobically packaged cooked chicken meat balls containing 50% skin and control meat balls are presented in Table 3.

Total plate count (log cfu/g)

Total plate count followed a significantly ($P<0.05$) increasing trend from day 0 to 14 in treatment samples as well as in control. Further coated meat balls had significantly ($P<0.05$) higher counts than uncoated meat balls on day 7 and 14. The coating might have an effect on reduction in total plate count of the product. This is in agreement with findings of Lazarus (1977), El-Ebzary et al. (1981) and Chidanandiah et al. (2009). A significant ($P<0.05$) increase in total plate counts of chicken meat balls stored under refrigeration was in agreement with findings of Nath et al. (1995), Kumar and Tanwar (2010) and Bhat et al. (2010) who also reported the similar results in chicken patties, chicken nuggets and chevon *Harissa* respectively.

Psychrophilic count (log cfu/g)

Psychrophilic count followed a significantly ($P<0.05$) increasing trend from day 7 to 14 in products containing skin as well as in control. A gradual increase in psychrophilic counts during storage of chicken products had also been reported by Sen and Sharma (1996), Nag et al. (1998), Chidanandiah et al. (2009), Sudheer et al. (2010) and Bhat et al. (2010).

Coliform count (log cfu/g)

The coliforms were not detected throughout the period of storage in both control and treatment samples. It could be due to the destruction of these bacteria at cooking temperature, much above their death point of 57°C. Further, hygienic practices followed during the preparation and packaging of meat balls could also be one of the reasons for the absence of coliforms. Similar results were reported by Dawson et al. (1975) in ground turkey patties, Kumar and Sharma (2004) in pork patties, Kandeepan et al. (2010) in buffalo meat keema and Bhat et al. (2010) in chevon *Harrisa* who also reported zero count of coliform for the product heated to such a high temperature.

Sensory attributes

The mean values of various sensory parameters of aerobically packaged cooked chicken meat balls containing 50% skin and control are presented in Table 3. The sensory attributes were significantly affected during 14 days of storage and all the sensory parameters viz. appearance, flavour, juiciness, texture and overall palatability followed a descending trend with increase in storage days. The decrease in appearance scores might be due to pigment and lipid oxidation resulting in non-enzymatic browning. A decrease in appearance and colour scores of meat products with increase in storage period was also reported by Nag et al. (1998) in chicken nuggets, Kumar and Sharma (2004) in chicken patties, Kilinc (2009) in anchovy patties, Chidanandiah et al., (2009) in buffalo patties and Bhat et al. (2010) in chevon *Harrisa.* The progressive decrease in flavour could be attributed to increase in thiobarbituric acid reacting substances value of meat product (Tarladgis et al. 1960) stored under aerobic conditions. Nag et al. (1998) also reported a decrease in flavour scores of chicken nuggets. Juiciness scores followed a decreasing trend throughout the period of storage. It could be due to some loss of moisture from the products during storage. The results were in accordance with findings of Nag et al. (1998). However, the juiciness scores of coated meat balls were higher than uncoated meat balls as a result of slightly higher moisture content. Coating application of various meats such as beef cut, pork and poultry parts resulted in less dehydration than from uncoated samples (Mountney and Winter 1961; Williams et al. 1978; Chidanandiah et al. 2009). Texture scores followed a decreasing trend throughout the period of storage. However scores were comparable in treated and control products throughout the storage period. Loss of moisture during storage caused the meat balls to retain lesser texture scores. Similar results were presented by Reddy and Rao (1997), Nag et al. (1998), Kilinc (2009) and Bhat et al. (2010) in chicken patties, chicken nuggets, anchovy patties and chevon *Harrisa* during refrigerated storage respectively. The overall palatability of chicken meat balls also decreased significantly throughout the period of storage. The decrease in scores during study might be reflective of the decline in scores of flavour, juiciness and texture attributes. These observations indicated that chicken meat balls prepared with 50% skin retained good to very good sensory attributes up to day 14 under refrigerated storage at 4±1°C in low density polyethylene pouches (LDPE).

Conclusions

The chicken meat balls from meat of spent hen can be successfully incorporated with skin. Based on the analysis of different sensory parameters, incorporation of 50% level of skin in the formulation was adjudged as optimum in both coated as well as uncoated meat balls. Chicken meat balls of very good palatability could be prepared by incorporating 50% skin in formulation substituting lean chicken meat from spent hen. Although, enrobing improved the sensory attributes, both coated as well as uncoated meat balls could be conveniently packed in LDPE pouches for a period of 14 days in refrigerated (4±1°C) condition without any marked loss of physicochemical, microbial and sensory quality. Thus, the present study showed successful utilization of skin, enrobing and spent hen meat in the preparation of meat balls.

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