Effect of post-mortem handling conditions on the quality of spent hen meat curry

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Abstract Study was performed to determine the effect of post-mortem handling conditions on the physico-chemical and sensory attributes of spent hen meat curry. Breast cuts of spent hens were subjected to different postmortem handling conditions before cooking viz; made into small cuts and cooked within 1–2 h of slaughter (condition 1), made into small cuts and cooked after 4–5 h of slaughter (condition 2), made into small cuts immediately after slaughter, stored at 4 ± 1 °C for 12 h and then cooked (condition 3), stored at 4 ± 1 °C for 12 h, made into small cuts and cooked (condition 4). The pH of meat just before cooking due to different stages of rigor development under various conditions differed accordingly. Observed differences in temperature of meat just before cooking were because of different postmortem handling condition variations viz:1,2,3,&4. The associated post mortem changes under different postmortem handling conditions before cooking led to significant variation in Water holding capacity, Water Soluble Protein, Salt Soluble Protein, cooking yield, moisture percentage before cooking and after cooking and also WB shear force value. In general, sensory scores were higher for conditions 4 and 1 as

compared to conditions 2 and 3. Results revealed that quality attributes of spent hen meat curry can be improved by following proper post-slaughter handling and processing conditions. To get meat curry of good sensory quality, meat should be cooked preferably within 1–2 h of slaughter or after 10–12 h of storage of intact carcass at 4 ± 1 °C. Cuts should be made just before cooking but cooking after 4–5 h of slaughter should be avoided.

Keywords Post-mortem handling · Spent hen · Meat curry · Quality characteristics

Introduction

Chicken has the distinction of the most liked meat in Indian subcontinent. The spent hens after the end of their economic laying cycle, also contribute a significant amount of the meat for domestic consumption. The meat from these birds remains tough and fibrous even after cooking in pressure cooker for long time during meat curry preparation. Improper handling and processing of such meat further deteriorate the quality of meat curry.

Meat curry is one of the most popular and most relished preparations in Indian households. Due to limited cold chain facilities, consumers usually purchase chicken carcass or cuts immediately after dressing or within 4–5 h of slaughter and cook at their home immediately or after storage in refrigerator for 10–12 h. For preparation of meat curry, the meat chunks are first partially fried and then cooked with condiments and water under pressure in pressure cooker. Cooked meat chunks with gravy are consumed along with rice or *chapaties*.

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Apart from the tough meat from spent hens, various post-mortem handling conditions prevailing during the period between slaughter and development of rigor mortis play very crucial role in determining quality of meat as several bio-chemical changes take place during this period (Savell et al. 2005; Mendiratta et al. 2008). It has been reported that handling conditions have significant effect on protein percent, pH, WHC, cooking loss, extractable proteins percent and sensory attributes (Kondaiah and Panda 1987; Mendiratta et al. 2008). Scheffler and Garrard (2007) reported that the rate and extent of pH decline during the conversion of muscle to meat had significant impact on development of fresh meat quality attributes. Even tenderizing agents have different effect on quality of spent hen meat when treated at pre-chilled or post-chilled stage (Naveena and Mendiratta 2001).

Thus different handling practices prevalent in developing countries might have great influence on quality of traditional meat preparations. However the scientific information on these traditional meat products particularly on chicken curry is very limited. Considering the above points, the present study was designed to evaluate the effects of commonly prevalent handling conditions on meat curry prepared from spent hen meat.

Materials and methods

Meat sources and handling conditions

In this experiments, total 40 spent white leghorn hens of at least 75 weeks of age were slaughtered under standard conditions in five batches (8 hens in each batch). Slaughtered birds were subjected to different handling conditions as per the requirement of experiment. The different handling conditions evaluated were:

- Condition 1: Dressing and cutting immediately after slaughter and cooking for preparation of curry within 1–2 h post-slaughter.
- Condition 2: Dressing of bird and then storage of dressed carcass for 4–5 h at ambient temperature ($25\pm 2^{\circ}\text{C}$), followed by cutting and cooking for preparation of curry.
- Condition 3: Dressing and cutting immediately after slaughter, followed by storage at $4\pm 1^{\circ}\text{C}$ for 12 h and cooking for preparation of curry.
- Condition 4: Dressing and storage of intact carcass at $4\pm 1^{\circ}\text{C}$ for 12 h followed by cutting and cooking for preparation of curry.

Temperature and Humidity Control Chamber (Scientific Equipment Works Delhi, India) was used for creating conditions of storage at ambient temperature. For refriger-

ated temperature storage, refrigerator (LG. Electronics model G.L-265TMG) was used.

Preparation of spent hen meat curry

Series of preliminary trials were conducted to select optimum level of different ingredients and cooking time for preparation of meat curry following the traditional method. The ingredients used and their levels (for 1 kg meat chunks) were : water (2,400 ml), condiments mix ie onion and garlic 3:1 (200 g), oil (100 ml), table salt (17 g), turmeric (4.01 g), chilly powder (2.99 g) and dried spice mix (16.49 g). The composition of dried spice mix (in per cent) used for meat curry preparation was: coriander powder (25.53), turmeric (17.08), capsicum (12.76), cumin seed (6.38), black pepper, cardamom and cloves (each 5.10), caraway seed, mace, cinnamon, aniseed (each 4.25), bay leaf (4.25) and nutmeg (1.70).

Spent hen meat chunks from breast cut were first partially fried with condiment mix, turmeric, *red chilli* powder and salt. For frying, open frying pan used. Frying of meat chunks with above mentioned mix was continued until colour changes to golden yellow (about 5 min) and then water was added and cooking was done in pressure cooking (Hawkins make kitchen pressure cooker) at 121°C for 28 min with occasional shaking of cooker. After opening of the lid, spice mix was added and contents were heated with continuous stirring for about 8 min. Cooked meat curry with sufficient thick gravy was collected, cooled at room temperature and evaluated.

Analysis of raw meat and cooked products

pH and temperature

The pH of raw (just before cooking) meat samples was determined by homogenizing 10 g of sample with 50 ml distilled water for 1 min in Ultra Turrex T25 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, Germany). The pH of the suspension was recorded by dipping the combined glass electrode of digital pH meter (Elico, India, Model LI 114).

Similarly, temperature of meat was also recorded just before cooking and after cooking by piercing the rod of digital probe thermometer (Fisher Scientific, China) in to the meat chunk.

Moisture content and cooking yield

The moisture content of raw and cooked meat samples was estimated by following gravimetric method of AOAC (2002).

The weight of meat chunks was recorded before as well as after cooking and cooking yield was expressed as percentage.

Water holding capacity (WHC)

Water holding capacity was estimated according to the method described by Wardlaw et al. (1973). Twenty gram minced meat sample was stirred with 30 ml of 0.6 M sodium chloride in a centrifuge tube. The tube was then kept at 4 ± 1 °C for 15 min, stirred again and centrifuged at 3,000 g (R-24, Remi Instrument, India) for 25 min. The supernatant was measured and expressed in percentage.

Extractable proteins

The procedure described by Kang and Rice (1970) was used with slight modifications for determination of salt soluble proteins (SSP) and water soluble proteins (WSP). 20 gramme of minced meat sample was homogenized with 50 ml chilled distilled water in a polycarbonate centrifuged bottle for about one minute in Ultra Turrex T25 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, Germany). Another 50 ml chilled distilled water was added and process was repeated. Volume was made to 200 ml with washings and sample was kept overnight in the refrigerator at 4 ± 1 °C. It was then centrifuged at 3,000 g (R-24, Remi Instrument, India) for 15 min. The fat layer was removed with the help of pre-sterilized spatula. The clean supernatant was carefully transferred to a beaker and the protein fractions (WSP) were estimated by Kjeldahl's method. The slurry was used for estimation of SSP in the same way as WSP from the supernatant where instead of chilled distilled water, 0.67 M NaCl solution was used to dissolve the slurry followed by re-centrifugation.

Shear force value

Shear force value of cooked chunks was estimated by placing the cores of samples in the blade attached to the Warner-Bratzler shear force apparatus (Model 81031307, G.R. Elect. Mfg. Co. USA). Cooked chunks were chilled overnight at 4 ± 1 °C and cores of 1.5 cm^3 were used for estimating the shear force values. Maximum force required to cut the sample was recorded and expressed in kg/cm^2 .

Sensory evaluation of meat curry

A trained sensory panel consisting of meat scientists of the division evaluated the meat curry for appearance (colour), flavour, juiciness, tenderness, connective tissue residue and overall palatability using 8 point descriptive scale (Keeton 1983), where 8 denoted excellent and 1 denoted extremely

poor. For connective tissue residue, 8 means minimum connective tissue and 1 means excessive connective tissue. The sensory evaluation was done in environmentally controlled (20 ± 2 °C) sensory evaluation laboratory with facility of individual booth for each panelist. Four samples (related to four handling conditions) were presented per season to each panelist. The temperature of the sample was about 50–55 °C during sensory evaluation.

Statistical analysis

The experiments were replicated five times and for every condition duplicate samples were used. Thus a minimum number of 10 observations for each condition were recorded for different physico-chemical parameters. Minimum 15 observations for each condition were recorded for shear force value. Five sensory panelists were used for each trial and thus total 25 observations were recorded for each condition for different sensory attributes. The statistical design of the study was 4 (treatment) X 5 (replications) randomized block design. The data was analyzed by SPSS statistical software package using one way analysis of variance. Duncan multiple range test and critical differences were determined at 5% significance level (Snedecor and Cochran 1989).

Results and discussion

Temperature and pH

Results of physico-chemical characteristics of raw and cooked meat samples are given in Table 1. The mean temperature values of raw meat samples (just before cooking) were significantly higher ($P<0.05$) for conditions 1 and 2 than conditions 3 and 4. However no significant difference was observed between conditions 3 and 4. Lower temperature in conditions 3 and 4 in comparison to conditions 1 and 2 was due of storage of meat at refrigerated temperature (4 ± 1 °C) before cooking. Temperature of meat immediately after cooking ranged from 79.8 to 80.3 °C and values did not differ significantly between different conditions.

The pH in condition 1 was significantly higher ($p<0.01$) than conditions 2, 3 and 4. The decrease in pH value of meat in conditions 2, 3 and 4 could be due to formation of lactic acid as a result of anaerobic glycolysis during storage (Savell et al. 2005). Significantly lower pH values of conditions 3 and 4 than condition 2 indicated that fall of pH continued even after 4–5 h of storage. Although pH value of condition 4 was lower than condition 3 but the difference did not turn out to be significant. This indicated that faster pH fall occurred in meat cuts than intact carcass.

Table 1 Quality characteristics of raw and cooked chicken meat subjected to different handling conditions*

	Condition 1	Condition 2	Condition 3	Condition 4
Physico-Chemical Parameters				
pH (Raw meat) (Just before cooking)	6.0±0.06 ^a	5.8±0.05 ^b	5.5±0.03 ^c	5.6±0.03 ^c
Temperature (°C) (Just before cooking)	23.0±0.22 ^a	20.3±0.25 ^b	5.4±0.16 ^c	6.2±0.18 ^c
Moisture (%) (Raw meat)	73.7±0.53 ^a	71.8±0.26 ^b	70.4±0.41 ^c	72.5±0.27 ^b
Water Holding Capacity (%)	48.4±4.32 ^a	46.3±4.12 ^{ab}	43.1±3.47 ^b	43.6±3.25 ^b
Water Soluble Proteins (%)	8.0±0.07 ^a	7.6±0.12 ^b	7.5±0.15 ^b	7.4±0.13 ^b
Salt Soluble Proteins (%)	13.3±0.42 ^a	12.5±0.23 ^b	12.2±0.08 ^b	12.0±0.16 ^b
Cooking Yield (%)	75.7±0.50 ^a	74.9±0.40 ^a	73.4±0.24 ^b	75.2±0.22 ^a
Moisture (%) (Cooked meat chunks)	56.9±0.13 ^a	56.0±0.18 ^{ab}	55.9±0.28 ^b	56.6±0.50 ^{ab}
W-B Shear force value (kg/cm ²)#	2.8±0.07 ^a	3.4±0.05 ^b	3.0±0.08 ^{ab}	2.6±0.06 ^a
Sensory Attributes ^{##}				
Appearance	6.9±0.08 ^a	6.8±0.08 ^a	7.0±0.08 ^a	7.0±0.06 ^a
Flavour	6.9±0.09 ^a	6.9±0.08 ^a	7.0±0.08 ^a	7.0±0.06 ^a
Juiciness	6.8±0.08 ^{ab}	6.6±0.09 ^b	6.8±0.07 ^{ab}	7.0±0.06 ^a
Tenderness	6.8±0.08 ^{bc}	6.6±0.08 ^c	6.8±0.09 ^{ab}	7.0±0.07 ^a
C. T. Residue	6.7±0.08 ^{ab}	6.5±0.08 ^b	6.7±0.09 ^{ab}	7.0±0.07 ^a
Overall palatability	6.9±0.06 ^{ab}	6.7±0.08 ^b	6.9±0.07 ^{ab}	7.1±0.06 ^a

Means with different superscripts in the same row indicate significant difference ($P<0.05$).

Number of observation: $n=10$, $\#n=15$, $##n=25$

* Condition 1 (cooking with 1–2 h of slaughter),

* Condition 2 (cooking after 4–5 h of slaughter),

*Condition 3 (cuts immediately after slaughter, stored at 4 ± 1 °C for 12 h and cooked)

*Condition 4 (stored at 4 ± 1 °C for 12 h, made into cuts and cooked)

Moisture content

The moisture percent of raw meat was significantly higher ($p<0.05$) for condition 1 and significantly lower for 3 than conditions 2 and 4 (Table 1). Decrease in moisture content in conditions 2, 3 and 4 in comparison to condition 1 could be attributed to evaporation losses during storage (Smith and Carpenter 1973). Huff-Lonergan and Lonergan (2005) reported that pH decline in early post mortem muscle may affect water loss during aging due to proteolytic disruption of intermediate filaments and the shrinkage of muscle fibers. Significantly lower moisture content for condition 3 than condition 4 could be due to more evaporative losses during storage from cuts in comparison to intact carcass. Greer and Jones (1997) also reported evaporative weight losses of up to 2% of the hot boned carcass during the initial 24 h of conventional air chilling of beef, pork and lamb.

The moisture percent of cooked meat curry chunks was significantly higher ($p<0.05$) for condition 1 than condition 3. However, non-significant differences were observed between conditions 2, 3 and 4. Higher moisture content of cooked meat chunks in condition 1 could be due to the fact that the pre-rigor muscle protein has higher water binding capacity than muscle protein in rigor state or post-rigor state. Almost similar findings for moisture content were also observed earlier in this laboratory in sheep meat curry subjected with different handling conditions (Mendiratta et al. 2008).

Water holding capacity

The mean WHC was highest in condition 1, followed by conditions 2, 3 and 4 (Table 1). Thus WHC decreased

significantly with increase in ageing time after slaughter. These trends of WHC can be correlated with decrease in pH (Savell et al. 2005) and rigor state (Hannula and Puolanne 2004). Higher WHC in hot meat samples could be due to higher pH values and larger space between the myofilaments and less denaturation of meat proteins (Loucks et al. 1984; Rosenvold and Andersen 2003). The difference in WHC in pre-rigor and rigor stage could also be due to difference in swelling of myofibrils (Kovacs 1996) and denaturation of sarcoplasmic and myofibrillar proteins (Scheffler and Garrard 2007).

Extractable salt soluble and water soluble proteins

Extractability of both water soluble and salt soluble proteins was significantly higher in condition 1 than conditions 2, 3 and 4. However no significant difference was observed between conditions 2, 3 and 4. Thus extractability of proteins decreased during storage of meat. In contrast to this, Naveena and Mendiratta (2001) reported higher extractability of protein in post-chilled chicken cuts (after 24 h of ageing) than pre-chill cuts.

Cooking yields

The cooking yield was significantly lower ($p<0.05$) for condition 3 than conditions 1, 2, and 4 (Table 1). However, there was no significant difference between conditions 1, 2 and 4. This difference in cooking yield values could be related to pH, WHC and time of making cuts and cooking (Devine et al. 2002 and Mendiratta et al. 2008). Loucks et al. (1984) and Claus and Sorheim (2006) reported higher

cooking loss for post rigor cooked meat than pre-rigor cooked meat. In the present study, higher cooking loss in condition 3 than condition 4, revealed more cooking loss when cuts were stored prior to cooking than the storage of intact carcass.

Shear force value

Significant differences were observed in shear force values of cooked meat chunks (Table 1). The mean value was significantly higher ($p < 0.01$) for condition 2 than conditions 1 and 4. However, non-significant differences were observed between conditions 2 and 3, and between conditions 1, 3 and 4. Significantly lower shear force value in condition 1 could be due to superior functionality (high pH, WHC, available energy and extractability of myofibrillar proteins) of meat within 1–2 h of slaughter (Claus and Sorheim 2006). Significantly lower shear force value in condition 4 than condition 2 could probably be due to start of resolution of rigor state after 10–12 h of slaughter. However, comparatively higher shear force in condition 3 than condition 4 could be due to severe contraction of muscle fibres during rigor in the cuts than in intact carcass.

Sensory attributes

Mean scores for appearance of spent hen meat curry ranged between 7.03 and 7.45 and the differences between different conditions were not significant (Table 1). Flavour and juiciness scores were significantly higher ($P < 0.05$) in conditions 1 and 4 than conditions 2 and 3. Non significant difference was observed between conditions 2 and 3. Juiciness score was significantly higher ($P < 0.05$) in condition 4 than 1, but flavour score did not differ significantly between conditions 1 and 4. Tenderness scores also differed significantly between different conditions. Score was highest for condition 4, followed by conditions 1, 3 and 2. Connective tissue residue and overall acceptability scores were significantly higher ($P < 0.05$) in condition 4 and significantly lower in condition 2 than conditions 1 and 3. Higher flavour and juiciness scores for roast cooked after hot boning were also reported by Loucks et al. (1984). Mendiratta et al. (2008) reported significantly higher tenderness score in sheep meat curry cooked within 1–2 h of slaughter and significantly lower scores in samples that were cooked after 5–6 h of slaughter. In contrast to these results, Sharma et al. (1988) reported lower tenderness scores for pre-rigor cooked meat.

Thus, in general sensory scores were significantly higher in conditions 4 and 1 and significantly lower in condition 2. Scores for condition 3 were higher than condition 2 but lower than conditions 1 and 4. The descending order for sensory

scores for all the sensory attributes was: condition 4 > condition 1 > condition 3 > condition 2.

The higher sensory scores and lower shear force values in conditions 4 and 1 could be due to many factors including pH, higher WHC and more extractability of myofibrillar and sarcoplasmic proteins (Claus and Sorheim 2006). Similarly, lower sensory scores and higher shear force value in condition 2 could be due to effect of shortening caused by onset of rigor mortis. Higher shear force value in condition 2 can also be correlated with higher muscle fiber diameter (Biswas et al. 1989; Dunn et al. 2000). Significantly lower scores in condition 3 than condition 4 could be due to severe shortening of muscle fibers of meat cuts in comparison to intact carcass. This shortening in conditions 2 and 3 could be the reasons for lower sensory scores and higher shear force value (Devine et al. 2002; Mendiratta et al. 2008). This variation between conditions 3 and 4 suggests significant negative effect of storage of cuts in comparison to storage of intact carcass.

Results of physico-chemical and sensory attributes revealed that the curry from spent hen meat should be preferably prepared within 1–2 h of slaughter or after 10–12 h of storage of intact carcass at $4 \pm 1^\circ\text{C}$. Preparation of curry after 5–6 h of slaughter and storage of meat cuts at refrigerated temperature before cooking should be avoided. To get curry of good quality, intact carcass should be stored at refrigerated temperature for at least 10–12 h before cooking.

The optimum post-slaughter handling conditions identified for spent hen can ensure effective utilization by providing tasty and tender meat curry to consumers. However, more detailed studies are required to evaluate biochemical and histological changes that are taking place under different handling and storage conditions prevalent in different parts of the world.

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