Effect of Post-slaughter Handling Conditions on Quality of Pork Curry

B.K. Sarkar, S.K. Mendiratta*, P. Prabhakaran, B.D. Sharma

Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar 243122

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ABSTRACT

Present investigation was designed to evaluate the effect of different handling conditions on quality of pork and pork curry. Carcass cuts from pigs of similar age (6-8 months), live weight (70-80 kg) and conformation were collected after slaughter and subjected to following treatments simulating different handling conditions viz., T$_1$-holding carcass cuts for 5-6 h at ambient temperature (20-25°C), followed by chunking/deboning and cooking of meat; T$_2$-holding carcass cuts for 10-12 h at ambient temperature (20-25°C), followed with chunking/deboning and cooking of meat; T$_3$-holding carcass cuts for 5-6 h at ambient temperature (20-25°C) and then chunking/deboning of meat, followed by storage of deboned meat in refrigerator (41°C) for 17-18 h and cooking and T$_4$-holding carcass cuts for 5-6 h at ambient temperature (20-25°C), followed by storage in refrigerator (41°C) for 17-18 h and then chunking/deboning and cooking. The results revealed that temperature, pH and WHC values of raw and cooked pork decreased with increasing storage time from 5-6 h to 24 h after slaughter. Pork achieved its ultimate pH within 10-12 h of storage at ambient temperature (20-25°C). Drip loss of raw meat was significantly (p<0.05) higher for T$_3$ than T$_2$. Total plate count increased with increasing storage time although, significantly (P<0.01) higher count were found in T$_2$ than other treatments. The Warner-Bratzler shear force value and sensory scores of cooked pork chunks were significantly (P<0.01) higher in T$_4$. Pork cooked within 5-6 h of slaughter scored significantly lower for the sensory attributes. This study revealed that pork may be cooked by consumers after 10-12 h of slaughter or after 24 h of chilling. Cooking of pork within 5-6 h of slaughter should be avoided and chunks should be made just before cooking.

Keywords: Handling condition, quality, pork, TPC

Introduction

Variation in meat tenderness and eating quality exists either at the time of slaughter or is created during post mortem storage or a combination of both. Method of meat preparations by consumers can also be a source of variation in meat tenderness. First 24 h of post mortem time is very important for muscle tissue as most of the biochemical and structural changes occur during this period. It has been reported that handling conditions affect the quality of fresh meat particularly protein percentage, pH, WHC, cooking loss, and extractable protein percentage (Kondaiah and Panda, 1987). Pre-rigor meat has high pH, responds well to electrical stimulation and has higher emulsifying capacity and greater extractability of salt soluble myofibrillar proteins (Myosin, actin, tropomyosin) than post rigor meat (Johnson and Henrickson, 1970). Significantly higher pH, moisture, cooking yield and sensory scores were observed for the sheep meat cooked within 1-2 hr of slaughter than the meat cooked after storage for 5-6 h (Mendiratta et al., 2008). Similar results were also observed during the study on effect of different handling conditions on quality of goat

*Corresponding author:

1Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Agartala, Tripura.
meat curry (Narayan, 2008) and buffalo meat curry (Majhi, 2009).

In India, carcass halves or primary cuts reaches the local meat retail shop within 2-3 h of slaughtering; and consumers usually purchase meat within 5-6 h and process the meat for preparation of meat curry and other traditional meat products as per their convenience either immediately after purchase or after storage in refrigerator for some time. Thus, from time of slaughter of animal till preparation of meat curry, cuts are exposed to different handling conditions. Mendiratta et al. (2008) reported that several post slaughter handling factors such as holding time after slaughter, deboning time and chilling before cooking play very important role in determining quality of meat curry. Further, pigs are frequently subjected to number of stresses before slaughter and these leads to undesirable quality of meat. Improper post slaughter handling conditions causes further deterioration in the quality of meat products. Therefore, evaluation of quality of meat curry prepared under Indian household conditions by subjecting the fresh meat to different post slaughter handling conditions may provide useful insights to recommend optimal handling conditions for consumers and others to obtain better eating quality. Very few published works are available in this aspect under Indian conditions. Hence, the present investigation was carried out to study the effects of commonly practiced post slaughter handling conditions on quality of pork curry.

Materials and Methods

Hams from pigs of similar age (6-8 months), live weight (70-80 kg) and conformation, slaughtered in experimental abattoir of the Livestock Products Technology Division, Indian Veterinary Research Institute, Izatnagar or in the local market of Bareilly were collected and utilized in this study. About 5 kg of meat (for each batch) was procured within 3-4 h of slaughter and brought immediately to the laboratory under hygienic conditions. External fat and fascia were trimmed off and meat was assigned to following treatments simulating different handling condition. T1 - holding carcass cuts for 5-6 h at ambient temperature (20-25°C), followed with chunking/deboning and cooking of meat; T2 - holding carcass cuts for 5-6 h at ambient temperature (20-25°C), followed with chunking/deboning of meat and then storage of deboned meat in refrigerator (4±1°C) for 17-18 h and cooking; T3 - holding of carcass cuts for 5-6 h at ambient temperature (20-25°C), followed by storage in refrigerator (4±1°C) for 17-18 h and then chunking/deboning and cooking. For refrigerated storage (4±1°C), refrigerator (LG. Electronic, Model: G.L-265TMG) was used. To get better and uniform product quality, meat chunks of 3.5-4.0 cm³ size were made from ham of pork and used in the study. Analytical grade and food grade chemicals were used in the study and were procured from standard firms. Ingredients used in pork curry including spice mix were procured from local market.

The refined oil was heated in the pressure pan and the condiments were added and fried. After that, turmeric, red chilli powder and salt were added and fried till golden yellow colour appeared. The meat chunks were then added and fried till the colour became brown. Water was then added and lid of the pressure pan was closed. Cooking under steam was done for 25 min. At the end the lid was opened; meat and gravy were stirred after addition of spice mix and left for simmering for 5 min. The prepared meat curry was transferred to a plate, cooled and evaluated. The following parameters were studied for evaluation of quality of pork curry.

pH

The pH of raw meat and meat curry was determined as per the method described by Trout et al. (1992). Ten grams of sample was homogenized with 50 ml of distilled water for about a minute in Ultra Turrex® T-18 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, USA). The pH was recorded by immersing the combined glass electrode of digital pH meter (Elico, India, Model: L1 114) directly into the meat suspension.

Water holding capacity (WHC)

The WHC of raw meat was determined as per the method described by Wardlaw et al. (1973) with slight modifications. Ten grams of finely minced meat carcass cuts for 10-12 h at ambient temperature (20-25°C), followed with chunking/deboning and cooking of meat; T4 - holding of carcass cuts for 5-6 h at ambient temperature (20-25°C), followed by storage in refrigerator (4±1°C) for 17-18 h and then chunking/deboning and cooking.
sample was homogenized with 15 ml of 0.6 M NaCl in a polycarbonate centrifuge bottle for about one minute in Ultra Turrex® T-18 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, USA). After holding for 15 min at 4°C in order to allow the 0.6 M NaCl to reach equilibrium, the meat slurry was again homogenized for 1 min and immediately centrifuged (REMI®-T23, India) at 5500 rpm for 10 min. The supernatant volume was measured and WHC was expressed as ml of 0.6 M NaCl retained by 100 g of meat.

**Drip loss**

The weight of meat chunks were recorded at 5-6 hr and just before cooking and drip loss was calculated and expressed in percentage as

\[
\text{Drip loss} \% = \frac{\text{Weight of raw meat chunks at 5-6 h - Weight of raw meat chunks just before cooking}}{\text{Weight of raw meat chunks at 5-6 h}} \times 100
\]

**Moisture**

Moisture content of raw meat and cooked meat chunks was determined as per the method of AOAC (2002).

**Total plate count**

The TPC of raw meat during different handling conditions was evaluated as per APHA (2001).

**Shear force value of cooked meat**

Cooked pork chunks (from meat curry) were cut into 1.25 cm³ cubes. The cut piece was then sheared in a Warner-Bratzler Shear Press (Model: No. 81031307, G. R. Elect. Mfg. Co., USA). The shear force was recorded (in kg/cm²) as per the method of Berry and Stiffer (1980). Ten observations were recorded for each sample to get the average value.

**Cooking yield**

The weights of meat chunks before and after processing were recorded and cooking yield was calculated and expressed in percentage as follows

\[
\text{Cooking yield} \% = \frac{\text{Weight of cooked meat chunks}}{\text{Weight of raw meat chunks}} \times 100
\]

**Sensory evaluation**

Standard sensory evaluation method using 8-point descriptive scale (Keeton, 1983) was followed with modifications where 8=excellent and 1=extremely poor. The panel (7 members) consisted of scientists and post-graduate students of Division of Livestock Products Technology, IVRI, Izatnagar. Samples were warmed (40-45°C) using a microwave oven (LG Electronics India Ltd., Mumbai) for 1 min and served to the panellists. Sensory evaluations were conducted between 3:30 and 4:00 pm and filtered tap water was provided to the panellists for rinsing their mouth in between evaluation of different samples.

**Statistical analysis**

The experiments were replicated a minimum of five times and the data were subjected to statistical analysis (Snedecor and Cochran, 1989) for analysis of variance (one way ANOVA) and Duncan’s multiple range test (DMRT) to compare the means and to find the effects of treatments.

**Results and Discussion**

The mean values of temperature (just before cooking) were significantly (p<0.01) higher for T₁ and T₂ than T₃ and T₄ in raw meat samples (Table 1). The mean value of T₂ was significantly (p<0.01) lower than T₁. The temperature decreased significantly (p<0.01) with increasing holding time of raw meat. The mean pH value of raw meat samples were significantly (p<0.01) higher for T₁ than T₂, T₃ and T₄. However, differences observed among T₂, T₃ and T₄ were non-significant which could be due to its pre-rigor state. The decrease in pH values with increasing holding time could be due to formation of lactic acid as a result of anaerobic glycolysis (Savell et al., 2005). Non-significant difference among T₂, T₃ and T₄ indicates that ultimate pH of pork reached within 10-12 h of slaughter when stored at ambient temperature (20-25°C). Stephens et al. (2006) reported that majority of pH decline occurred during the first 3 h after slaughter in pork. Significantly (p<0.01) higher cooked meat pH value was recorded in T₁ than T₂, T₃ and T₄ which could be due to higher initial pH i.e. cooking of meat at pre-rigor state and similarly lower pH values in T₂, T₃ and T₄ could be due to cooking of meat after attaining
Table 1: Physico-chemical and functional properties of raw and cooked pork curry (Mean±SE)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
<th>Treatment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw meat</strong></td>
<td></td>
<td></td>
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<tr>
<td>Temperature (ºC)</td>
<td>24.82±0.35&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.86±0.48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.40±0.58&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.28±0.26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH</td>
<td>6.29±0.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.39±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.45±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.38±0.12&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>WHC (ml/100g)</td>
<td>23.00±1.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.50±0.94&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>17.48±0.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.50±0.61&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>76.90±1.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75.96±0.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.71±0.49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>76.18±0.75&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Drip loss (%)</td>
<td></td>
<td>0.39±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.81±0.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.06±0.17&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>TPC (log cfu/g)</td>
<td>4.45±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.88±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.24±0.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.79±0.13&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Cooked meat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.01±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.72±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.64±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.70±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>62.46±0.72&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.95±0.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>60.56±0.73&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>59.64±0.69&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>WBSFV (kg/cm²)</td>
<td>5.66 ± 0.14&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.03 ± 0.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.30 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.08 ± 0.11&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Cooking Yield (%)</td>
<td>71.13±1.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.15±0.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.33±1.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>66.30±1.99&lt;sup&gt;ab&lt;/sup&gt;</td>
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</table>

Mean with different superscripts in the same row indicate significant difference (P<0.05); Number of observation: n=5, **n=30


Table 2: Sensory evaluation scores of pork curry of different holding conditions (Mean ± SE)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
<th>Treatment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>6.52±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.84±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.83±0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.29±0.06&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flavour</td>
<td>6.50±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.90±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.84±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.30±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tenderness</td>
<td>6.20±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.60±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.76±0.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.29±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Juiciness</td>
<td>6.46±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.76±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.66±0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.29±0.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overall palatability</td>
<td>6.36±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.77±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.80±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.34±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
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</table>

Means with different superscripts in the same row indicate significant difference (P<0.05); Number of observation: n=30; 8-point descriptive scale (1= Extremely undesirable, 8= Extremely desirable)

The mean value of water holding capacity of raw pork sample was significantly (p<0.01) higher in T<sub>1</sub> compared to T<sub>3</sub> and T<sub>4</sub>. However, non-significant differences were observed between T<sub>1</sub> and T<sub>2</sub>, and between T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> which indicated that water holding capacity decreased with increase in storage or holding time after slaughter. Non-significant difference between T<sub>3</sub> and T<sub>4</sub> indicated that deboning and chunking of pork before or after refrigeration did not significantly affect the water holding capacity of raw pork. Raj <em>et al.</em> (2000) also reported that initial values of WHC of buffalo loin muscles gradually decreased during chilling. The trends of WHC can be correlated with decrease in pH and carcass temperature (Savell <em>et al.</em>, 2005) and rigor state (Hannula and Poulanne, 2004).

The mean values of moisture content of raw meat
differed non-significantly from each other. The moisture of cooked pork chunks were significantly (p<0.05) higher for T1 than T2 and T4. However, non-significant difference was found among T2, T3 and T4, and between T1 and T3. Mendiratta et al. (2008), Narayan (2008) and Majhi (2009) also observed lowered moisture percentages when sheep, goat and buffalo meat were cooked after storage.

Drip loss was significantly (p<0.05) higher for T3 than T2. However, non-significant differences were observed between T2 and T4 and between T3 and T4. Drip loss observations revealed that drip loss increased with post slaughter holding time and especially when deboning and chunking was done before refrigeration storage. This is due to increase surface area after deboning and chunking. Low drip loss in T2 could be due to handling for only few hours and can be correlated with its high pH and WHC than in T3 and T4. In contrast to this, Schwegele et al. (1991) reported reduction in drip loss in pork after hot-boning.

The mean shear force values were significantly (p<0.01) lower for T3 and T4 compared to T1 and T2. Non-significant difference between T2 and T4 revealed that chunking/deboning before or after refrigeration storage did not significantly affect the shear force value of pork. Mean value for T2 was significantly (p<0.01) lower than T1. These results revealed that shear force value decreased with increasing holding times. Devine et al. (2002) also reported significant effect of temperature on shear force value after 5-6 h of slaughter. Significantly higher shear force value in T1 could be due to setting of rigor after 5-6 h of slaughter (Mendiratta et al., 2008; Gracey et al., 1998) and due to its maximum rigidity during rigor phase (Gracey et al., 1998). Higher shear force value in T1 could also be due to higher muscle fibre diameter (Dunn et al., 2000). Significantly lower shear force values in T2, T3 and T4 when compared to T1 could probably be due to start of resolution of rigor state within 10-12 h (Gracey et al., 1998).

The cooking yield was significantly (p<0.05) higher in T1 than T2 and T3. However, non-significant differences were observed between T2, T3 and T4, and between T1 and T4. Results revealed that cooking yield decreased with increasing holding time after slaughter. Differences in cooking yield values could be due to the difference in pH, moisture and WHC values of different handling conditions. Mendiratta et al. (2008) and Narayan (2008) also observed decreased cooking yield values during storage of sheep and goat meat, respectively.

The mean total plate count value was significantly (p<0.01) higher for T2 compared to conditions T1, T3 and T4. However, non-significant differences were observed between T1 and T4 and between T3 and T4. Thus increase in microbial count was significantly (p<0.01) higher after storage for 10-12 h at ambient temperature than storage for 24 h at refrigerated temperature. Majhi (2009) also observed similar results in buffalo meat handling conditions. Narayan (2008) also reported increased TPC values with increasing storage time.

**Sensory attributes**

The mean appearance, flavour and tenderness scores (Table 2) were significantly (p<0.01) higher for T4 than conditions T1, T2 and T3. However, scores T2 and T3 did not differ significantly. The mean juiciness score was significantly (p<0.01) higher for T4 than T1, T2 and T3. However, non-significant differences were observed between T1, T2 and T3. The mean overall acceptability score was significantly (p<0.01) higher for T4 and significantly (p<0.01) lower for T1. However, T2 and T3 did not differ significantly.

Thus in general, sensory scores were higher in T4 and lower in T1. Scores for T2 were higher than T1 and T2 but lower than T4. However, T3 and T4 did not differ significantly. Mendiratta et al. (2008), Narayan (2008) and Majhi (2009) also reported significant variations in sheep meat curry, goat meat curry and buffalo meat curry repetitively, subjected to different handling conditions. They reported significantly lower sensory scores for sheep and goat but higher score for buffalo meat curry after 5-6 h of slaughter. The enhanced tenderness of slowly chilled meat has been attributed to the earlier onset of proteolytic breakdown of the myofibrillar structure (Hostetler et al., 1975). Jaime et al. (1992) studied the effect of rapid drop of post mortem temperature during
rigor and reported high sensory scores after rigor at 0°C due to higher pH and rapid increase of sarcoplasmic Ca++ level. The differences in quality attributes of different handling conditions could also be due to differences in rate and extent of pH fall (Scheffler and Gerrard, 2007).

Temperature, pH and WHC values of raw pork decreased with increasing storage time after slaughter. Pork achieved its ultimate pH within 10-12 h of storage at ambient temperature (20-25°C). Total plate count increased with decreasing storage time. Increase was significantly (P<0.01) higher when carcass cuts were stored at ambient temperature (20-25°C) for 10-12 h compared to 24 h storage at refrigeration temperature (4±1°C). Increased storage time after slaughter resulted in decreased Warner-Bratzler Shear Force Value of cooked pork chunks. Holding of carcass cuts for 5-6 h at ambient temperature (20-25°C), followed by storage in refrigerator (4±1°C) for 17-18 h, chunking/deboning and cooking scored significantly higher for all the sensory attributes. Thus, pork should be cooked after 10-12 h of slaughter or after 24 h of chilling, and cooking within 5-6 h of slaughter should be avoided.

References


