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Meat Quality and Storage Characteristics Depending on PSE Status of Broiler Breast Meat

H. S. Chae, N. K. Singh[1], Y. M. Yoo*, C. N. Ahn, S. G. Jeong, J. S. Ham and D. H. Kim
National Livestock Research Institute Rural Development Administration, 77 Chooksan-gil
Kwonsun-gu, Suwon, 441706, Korea

ABSTRACT : The pale, soft, exudative (PSE) syndrome lowers storage quality and consumers acceptability in the particular meat. With the increase in the consumption of parted chickens in Korean meat consumption trade, a parallel increase in the concern over the PSE status of chickens have been noticed. The present study focused on the PSE status of broiler's breast to investigate the effects of different degrees of PSE on its quality and storage characteristics. A total of 46 broiler chickens of 35 days old averaging 1,251-1,350 g were selected for the study. Breast separated and skin was removed. The breast meat was stored at 4°C for 3 days and were analysed for pH, lightness, yellowness, redness, shear force, water-holding capacity (WHC), cooking loss, Thiobarbituric acid reactive substances (TBARS) and Volatile basic nitrogen (VBN) on day 1 and 3 during the storage. Increase in the degree of broilers breast PSE during storage caused fall in pH and shear force and increase in lightness, cooking loss, TBARS, VBN. Broilers breast PSE status confirms the actual pale soft and exudative nature of meat. (**Key Words :** Broilers Breast, PSE, Storage Characteristics, Meat Quality)

INTRODUCTION

The pale, soft, exudative (PSE) is an important quality defect in pigment and concerns more than 60% of consumers standing in front of the meat counter (Lee and Choi, 1999). This syndrome leads to meats, having a paler color, a higher toughness and a lower water holding capacity. In pork, this phenomenon is well known whereas, in turkey reports are sparse and in chicken it is almost negligible. Observations have revealed (USA data) that PSE occupies 5-30% of the slaughtered turkeys (Barbut, 1996; McCurdy et al., 1996). Froning et al. (1978) showed that turkeys exposed to pre-slaughtered stresses, such as struggling or heat, exhibit an accelerated pH decline which later resulted in tougher breast meat. Van Hoof (1979) suggested that turkey breast muscle is susceptible to a PSE-like condition described in pork. In spite of such interventions and reporting little attention was drawn to this problem. Overall, glycolysis in poultry muscle is much faster than in red meat species (Addis, 1986), but within this glycolysis rate, some variation can be observed. In broilers meat, Simpson and Goodwin (1975) reported that plant, sex and season had a significant effect on meat tenderness. They also mentioned that breast meat pH values appeared to be higher in the winter. Warris and Brown (1987) have reported that early postmortem pH decline from 30 min to 1 h was the most important factor which determined the degree of exudation in pork. Early studies by Bendall and Wisman-Pedersen (1962) have also reported that rigor development in pork muscle at elevated post-mortem temperatures of 37°C always resulted in PSE meat characteristics. It is generally accepted that pHu values, measured at 24 h postmortem, of PSE meat are similar to those of normal meat. So, the rate of pH fall seems to be the major factor, determining the severity of problems associated with PSE meat. The inter-relationship between temperature and pH in the development of PSE characteristics is also important and well established (pork: Fernandez et al., 1994a). McKee and Sams (1998) have subjected turkey carcasses to high temperature. They have performed several measurements during the 4 h post-mortem when carcasses were kept at high temperature. In their study, carcasses kept at 40°C presented the PSE characteristics. Recently, an increase in the consumption of parted chicken have been noticed in Korean consumption trade due to increase in the companies franchisee. However,

* Corresponding Author: Young-Mo Yoo. Tel: +82-31-290-1688, Fax: +82-31-290-1697, E-mail: yooym@rda.go.kr
[1] Surgery Div., SKUAST-J, Jammu, India.
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Table 1. Relation between PSE and pH of meat breast (%)

Items	Aver. pH	pH range		
		<6.0	6.0-6.2	>6.2
Normal	6.10±0.13*	23.3	53.3	23.3
PSE (Slight)	5.95±0.06	80.0	20.0	-
PSE (Serious)	5.87±0.12	100	-	-

* Means±SE.

there is growing concern over the PSE status of parted chicken among consumers because of the visibility. Certain advanced countries have been practicing regulations for parted chicken. United States follows USDA, 1998 (3 step system) for the quality grading of poultry parts whereas Japan and UK (MAFF, 1999) follow 2 step system for the same. In Korea, regulations related to parted has not been undertaken seriously. Whole chicken has basically 3 large parts i.e. Breast, legs and wings. Consumers who preferred drum sticks recently shifted to breast parts because of its lower fatness. PSE status being detrimental factor for meat quality if not properly determined and contained would drastically affect the economy of chickens meat industry. The present study focused on the PSE status of broilers breast to investigate the effects of different degrees of PSE on its quality and storage characteristics.

MATERIALS AND METHODS

Samples were collected from the large scale slaughter house (70,000 birds/day). A total of 46 broiler chickens of 35 days old averaging 1,251-1,350 g were selected for the study. Breast separated and skin was removed. Breast meat was stored at 4°C for 3 days and were analyzed on day 1 and 3 during the storage. The pH was measured using portable needle-tipped combination electrode (NWK binar Ph-K21, Germany) in the geometric center of the breast muscle. Water-holding capacity (WHC) was determined by a centrifugation method (Kristensen and Purslow, 2001) with the following modification. One (1) g of homogenized tissue was placed in a 2 ml centricon tube (VIDAS, France). The sample containing tube was then placed in a 50 ml centrifugation tube, heated in a 70°C water bath for 30 min, and centrifuged at 100 g (Hitachi, SCR20BA, Japan) for 10 min at room temperature (approximately 18°C). WHC was expressed as a percentage of weight loss of sample tissue during the centrifugation. Percentage of water content was determined by weight loss of 5 g muscle tissue at 102°C for 24 h. Cooking loss was determined by calculating percentage of weight loss of 150 g meat sample during 40 min cooking at 80°C in a water bath. Shear force was analyzed by method described by Chae et al. (2005). Chicken's breast was cut as steak shape (100×60×25 mm thickness; average weight, 61 g) and cooked to an internal temperature of 80°C in the waterbath for 1 h. The cooked samples were paralleled with fiber direction using the core (0.5 inch diameter) and WB-shear force (WBS) was measured by shear force meter (Warner-Bratzler, USA). Color values on freshly cut surface of the chicken breast were measured by a chroma meter (Minolta Co. CR 301, Japan) for lightness (L*), redness (a*) and yellowness (b*) of CIE* after a 30-min blooming at 1°C. Thiobarbituric acid reactive substances (TBARS) was determined as described by Witte et al. (1970) and expressed as mg malonaldehyde equivalents/kg sample, using 1,1,3,3,- tetramethoxypropane as a standard precursor of malonaldehyde. Percentage of TBARS inhibition was determined by applying the equation: inhibition = (1-control sample)×100. Volatile basic nitrogen (VBN) was determined as described by Park et al. (1998). The statistical analysis of PSE, TBARS, VBN and physical characteristics were done using Duncan's multiple range test (SAS, 1997).

RESULTS

pH measurements

Breast PSE examination revealed that PSE meat either slight or serious was having low pH range below 6.0 in 80-100% of the samples compared to normal PSE (23.3%) (Table 1).

Color measurements

Seventy to 100% samples either slight or serious PSE was observed to have lightness more than 67 compared to normal. Only 20% of the slight PSE was below 64 whereas none of the sample in serious PSE was either in the range of 64 to 67 or less than 64 (Table 2). Almost 100% of the samples showed the redness range of 3 to 6. Fifty percent of the slight PSE was less than 3, whereas 20% was in the range of 3-6, another 20% was between 6-9 and only10% was above 9. The average redness for slight PSE was 4.23±4.01. 73.3% was found to be below 3 and 3.3% was in the range of 3-6. 10% was between 6-9 and 13.3% samples

Table 2. Relation between PSE and lightness (L*) of breast meat (%)

Items	Aver. L*	CIE (L*) range			
		<64	64-67	>67-70	>70
Normal	65.04±4.08*	36.7	30.0	23.3	10.0
PSE (Slight)	67.93±4.43	20.0	10.0	50.0	20.0
PSE (Serious)	69.29±2.25	-	-	33.3	66.6

* Means±SE.

Table 3. Relation between PSE and TBARS of breast meat during storage (mg MA/kg)

Items	1 day	3 day
Normal	0.032±0.006[b]	0.052±0.007[b]
PSE (Slight)	0.023±0.002[c]	0.065±0.006[ab]
PSE (Serious)	0.041±0.004[a]	0.075±0.011[a]

[a, b, c] Means±SE in the same row with different superscripts differ significantly (p<0.05).

Table 4. Relation between PSE and VBN of breast meat during storage (mg %)

Items	1 day	3 day
Normal	10.33±0.47[b]	11.25±0.47[a]
PSE (Slight)	11.36±0.61[a]	11.61±0.82[a]
PSE (Serious)	11.01±0.47[ab]	11.85±0.42[a]

[a, b, c] Means±SE in the same row with different superscripts differ significantly (p<0.05)

were observed to be above 9. The average redness calculated for normal PSE was 3.54±3.53. The average yellowness was 12.68±4.09 (serious), 11.93±3.70 (slight) and 8.39±3.01 (normal). The average yellowness followed an increasing pattern with the increase in the degree of PSE.

TBARS/VBN measurements

TBARS values showed increasing trend with the degree of PSE during storage. The values were found to be significantly different ($p<0.05$) for slight and serious PSE compared to normal (Table 3). VBN values for slight and serious PSE were significantly different on day 1 compared to normal (Table 4).

Physical characteristics measurements

The cooking loss % during storage showed an increasing trend with increase in the degree of PSE. Slight and serious PSE were significantly different ($p<0.05$) compared to the normal. Decreasing trend was also observed in shear force during storage (Table 5). However, there was no significant differences were observed. No significant variation was noticed in terms of shear force and water holding capacity among normal, slight and serious PSE breast meat during 1 and 3 day storage.

DISCUSSION

Pale colour is one of the main indicators of PSE meat (pork: Vander Wal et al., 1988; Warner et al., 1997; turkey: Barbut, 1993, 1996, 1998; chicken: Barbut, 1997). In this study, higher L^* values (>70) were found in serious PSE than slight and normal PSE after 24 h of storage at refrigerating temperature. Degree of redness and yellowness also showed similar pattern in serious PSE when compared to slight and normal PSE. There are no reports related to lightness and degree PSE of chickens breast meat. However, there are reports in turkeys that the higher values of lightness were related to early postmortem time (McKee and Sams, 1998). In pork meat, Bendell and Wismer-Pedersen (1962) suggested that change in L^* values could be explained by protein denaturation, and more precisely by sarcoplasmic proteins which increases the light scattering. Froning et al. (1978) also reported that lower values of L^* for meat of turkeys subjected to acute heat stress immediately before slaughter. On the contrary, McKee and Sams (1997) reported higher L^* values for muscles of turkeys subjected to heat stress. In the present study, the higher L^* values for chicken's breast meat could further be related to protein denaturation and probable changes in the sarcoplasmic proteins due to heat stress of the season (June month of the year) (Bendell and Wismer-Pedersen, 1962). Researchers opined that generally PSE appears when a low pH and high muscle temperature are encountered. This is generally happens when the postmortem glycolysis is dramatically accelerated. Nevertheless, Rathgeber et al. (1999) have shown that rapid and normal glycolysing turkeys exhibited same L^* values at 24 h post-mortem.

To the contrary, 80 to 100% of chickens breast with slight and serious PSE showed pH less than 6 when compared to normal and ultimately effected the color values of meat.

Storage temperature in the present study found to have no better effect on the breast meat to prevent fall in pH. Authors opined that the glycolysis process once resumed after slaughter would not be countered further during storage. The fall in pH could be attributed to heat stress before slaughter during the season. This fact was further supported by Simpson and Goodwin (1975) who reported that season had significant effect on the meat tenderness. They also mentioned that breast meat pH was higher in the winter. In the study broilers were collected during June month of the year and during this month the temperature was around 30°C. The seasonal temperature might have been responsible for further decline in pH and to bring

Table 5. Physical characteristics of breast during storage

Items	Cooking loss (%)		Shear force (kg/0.5 inch^2)		Water holding capacity (%)	
	1 day	3 day	1 day	3 day	1 day	3 day
Normal	15.54±2.06[c]	18.60±1.12[b]	1.73±0.19[a]	1.66±0.44[a]	61.17±1.94[b]	61.44±2.14[b]
PSE(Slight)	18.19±1.02[b]	20.31±2.12[b]	1.68±0.44[a]	1.35±0.46[a]	65.18±0.72[a]	65.14±1.01[a]
PSE(Serious)	23.49±1.08[a]	24.04±0.95[a]	1.38±0.18[a]	1.21±0.38[a]	64.42±1.43[a]	60.26±0.84[b]

[a, b, c] Means±SE in the same column with different superscripts differ significantly (p<0.05).

about deleterious effects on the PSE status of breast meat. Sante et al. (1991) reported that the rate of early postmortem pH decline was 1.4 times faster in high performance turkey breed compared to a slow-growing breed. Fall in pH could be due to the faster growth of the broilers and could be concluded that onset of rigor in the pectoralis muscle was rapid and similar to PSE in pig meat.

Exudative meat represents the last, but not the least characteristics of PSE syndrome. In our study, water holding capacity during storage was quite high for normal chicken breast. However, the values were found to be very low for serious PSE on day 1 and 3 during storage. There was significant change in the WHC in slight PSE between day 1 and 3 of storage. The fall in WHC of slight PSE revealed that storage temperature could not prevent the drip loss reflects that low temperature storage of PSE meat does not alter the quality of PSE of breast meat of broiler chicken irrespective of the nature of PSE either slight or serious. In various studies on poultry, drip loss was found to be higher for PSE meat than for non-PSE meat (Turkey: McKee and Sams, 1998; Wynveen et al., 1999; Owen et al., 2000; chicken: Van Laack et al., 2000). To our knowledge, no study reported WHC during storage in PSE chicken's breast meat. Some sparse reports on drip loss related to poultry have been only documented by Molette et al. (2003). In the present study, the cooking or thawing losses were not significantly different between slight and serious PSE. This lack of differences can be explained by the large quantities of exudates lost by slight and serious PSE during storage. Hahn et al. (2001) also reported no differences in cook and thawing losses between normal and rapid glycolysis in turkeys. Froning et al. (1978) reported differences in cooking loss but not in thawing loss.

Shear force is an indicator of tenderness of meat. Shear force was found to decrease non significantly in normal, slight and serious PSE. Although, the fall in the values were seemingly high for slight and serious PSE but were not significant. Shear force reflects tenderness of meat is considered one of the organoleptic traits of PSE meat. Several authors reported decreased tenderness for PSE meat (Turkey: Froning et al., 1978; Barbut, 1993; McKee and Sams, 1997; Pork: Vander Wal et al., 1988). Several authors have explained the shear force in terms of tenderness and reported that ageing is the primary factor which hastens the process of fall in shear force which explains the differences in the texture of any given meat (Boles et al., 1992; Fernandez et al., 1994b; Minelli et al., 1995). Author explains the fall in shear force is directly or indirectly related to protein denaturation which leads to decline in WHC and thereby increase driploss (Molette et al., 2003).

TBARS values as indicator of lipid oxidation have been used by numerous researcher (Kamil et al., 2002; Jeon et al., 2003). However, the parameters have not been related to PSE meat of poultry. Pig meat is susceptible to oxidation due to its high concentration of polyunsaturated fatty acids compared to beef and lamb meats (Pearson et al., 1977). Whether poultry is susceptible to oxidation is not known till date. However, it can be inferred from the TBARS analysis from the present study that PSE chickens breast meat either slight or serious in nature are susceptible to lipid oxidation during storage when compared to the normal. VBN is a measurement of the nitrogen component of protein degradation, but also includes metabolite products such as AMP (Takasaka, 1975). VBN has not been determined or reported for chickens PSE meat. In the present study there was considerable increase in the values of VBN particularly in slight and serious PSE compared to normal, however, the values statistically appeared non significant. It has been well documented that structural and cytoplasmic proteins of meats are exposed to proteolytic actions of endogenous proteolysis during ageing, leading to the production of polypeptides (Park et al., 2007; Hwang et al., 2004a) The degradation of products consequently generate small peptides and free amino acids by subsequent actions of peptidases and aminopeptidases, respectively (Toldra and Flores, 2000). Furthermore activities of endo- and exo-proteases, peptidases and aminopeptidases are significantly affected by pH and temperature interactions during the onset of rigor mortis (Toldra and Flores, 2000; Hwang et al., 2004b). This is hypothesized that storage temperature might have prevented endogenous proteolysis to some extent to be notified as non significant value.

CONCLUSION

Increase in the intensity of broilers breast PSE during storage revealed fall in pH, shear force and increase in lightness, cooking loss, TBARS and VBN. Seriousness of PSE apparently speaks about the quality of broilers breast meat. Breast PSE status confirms the actual pale soft and exudative nature of meat.

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