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Incidence and Physical Properties of PSE Chicken Meat in a Commercial Processing Plant

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■ Keywords

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ABSTRACT

It is known that PSE meat present important functional defects, such as low water holding capacity and ultimate pH, which may compromise the quality of further-processed meat products. In this study, L* (lightness), a* (redness), and b* (yellowness) values of 500 chicken breast fillets were determined using a portable colorimeter (Minolta, model CR-400) in a commercial processing plant. Fillets were considered pale when their L* was ≥49. Out of those samples, 30 fillets with normal color and 30 pale fillets were evaluated as to pH, drip loss, cooking loss, water holding capacity, shear force, and submitted to sensorial analysis. An incidence of 10.20% PSE meat was determined. Pale and normal fillets presented significantly different ($p \leq 0.05$) pH values, L* and a* values, water holding capacity, drip loss, and cooking loss, demonstrating changes in the physical properties of PSE meat. Shear force and sensorial characteristics were not different ($p > 0.05$) between pale and normal fillets. Despite the significant differences in meat physical properties, these were not perceived by consumers in terms of tenderness, aspect, and flavor. The observed incidence of PSE may cause losses due to its low water retention capacity.

INTRODUCTION

Poultry meat production has undergone many changes in the last few years. Parts are increasingly sold relative to whole carcasses. Moreover, there is an increasing number of further-processed products, such as nuggets, breaded and other ready-to-cook and ready-to-eat products, available in the market. However, the quality of these products is directly related to the quality of the meat used to prepare them.

According to the Brazilian Poultry Association (União Brasileira de Avicultura - UBA, 2008), Brazilian chicken production exceeded the volumes sold in previous years both in the domestic and international markets. Exporters expect to obtain significant increase in sales, particularly as new markets are opened. One of the factors that allowed Brazil to become the largest global chicken meat exporter in terms of revenue was the increase in the sales of chicken parts and further-processed products, which have higher added value.

A significant proportion of chickens is deboned for breast exports, and consequently, meat quality defects, such as PSE (pale, dry, and exudative meat), result in important losses for chicken meat industry. In addition, taking into account the increasing number of further-processed chicken meat products in the last few years, it is essential for processors to have correct information on PSE meat (Komiyama, 2006).

PSE meat is a meat quality defect that affects important meat physical properties, such as water holding capacity and ultimate pH, which may reduce the quality of further processed chicken meat products (Komiyama, 2006).

PSE is the acronym for Pale, Soft, and Exudative, which indicate that the meat is pale or yellowish, flaccid or soft, and exudative or wet (Olivo & Shimokomaki, 2006). In practice, it results from poor and stressful handling of animals ante-mortem, causing an acceleration of rigor mortis (Ludtke, 2009). The condition is explained by a pH usually lower than 5.8 combined with high muscle temperature - usually higher than 35°C - at the beginning of rigor mortis (Takahashi et al., 2008). This is due to the rapid metabolic transformation of glycogen into lactic acid, which results in achieving ultimate pH before carcass cools, causing protein denaturation, and consequently, meat becomes pale, soft, and exudative and have its functional qualities compromised (Komiyama, 2006; Ludtke, 2009).

PSE meat is internationally recognized as severe problem for the meat industry, and has been studied for many years due to its considerable economic importance (Fletcher et al., 2002). The first studies were carried out with pigs, and then expanded to turkeys. It was verified that 41% of turkey meat may present PSE characteristics, and, recently, that in chickens, this percentage may reach 47% (Woelfel et al., 2002).

PSE meat is not well accepted both by consumers, who usually purchase products based on their appearance, and processors. In processing, PSE meat is inadequate not only because of its pale color, but also due to its high drip loss, cooking loss, reduced juiciness, and poor emulsifying capacity (Johnston et al., 2005).

Whereas tenderness is one of the main sensorial attributes that determine global acceptability, meat color is associated to acceptability at purchase (Bressan & Beraquet, 2002; Sanders et al., 1997). A wide range of chicken breast fillet colors, from very pale to very dark extremes, was found in processing plants of many countries (Qiao et al., 2001). The lack of color uniformity is considered a negative aspect of chicken fillet quality as, according to Wilkins et al. (2000), color differences may reduce product acceptability.

Barbut (1997) observed that chicken PSE meat incidence ranged from 0 to 28% in different processing plants. Lara (2003) studied the incidence of PSE meat in broilers submitted or not to stress in the pre-slaughter period and found incidences of 35.30% and 37.08% for non-stressed and stressed birds, respectively.

Based on these considerations, the present study aimed at evaluating the incidence and physical properties of PSE chicken meat in a commercial processing plant.

MATERIAL AND METHODS

This study, carried out at the School of Agricultural Sciences of the Federal University of Grande Dourados, MS, Brazil, surveyed the incidence of PSE in an integrated company located in Dourados, MS, Brazil.

The percentage of carcasses with PSE meat characteristics was determined evaluated relative to the total number of slaughtered birds. The processing plant was visited on a hot day during winter, with 26°C and 32°C of minimum and maximum environmental temperatures, respectively, and relative humidity of 65%. Chicken fillets were evaluated and samples in the processing line.

Breast fillets (n=500) were classified in the deboning line as a function of color, evaluated by L* (lightness), a* (redness), and b* (yellowness) readings using a portable colorimeter (Minolta model, CR-400). Readings were carried out at 0 (immediately after deboning), 4, and 24 hours post mortem, on the ventral surface of the breast fillet (Pectorales major) in order to prevent any interference of scalding. Samples were considered pale when their L* value was equal or higher than 49 in the first reading.

Out of the breast fillets classified as PSE and normal, 30 normal and 30 pale fillets were selected for the evaluation of pH, color, drip loss, water holding capacity (WHC), cooking loss, shear force, and sensorial analysis.

Breast fillet pH was directly measured using a pHmeter with 0.01 precision (Sentron, model 1001) coupled to a probe (Sentron, type LanceFET, model 1074001) with a thin penetrating needle inserted in the center of the Pectoralis major muscle, 0.5 to 1.0cm below the muscle surface. Measurements were carried out at 0 (immediately after deboning), 4, and 24 hours post mortem.

Drip loss was determined according to the methods of Northcutt et al. (1994) and Dirinck et al. (1996). Breast fillet samples were removed from the carcasses 24h post mortem, weighed, and stored in polyethylene trays covered with waterproof plastic film at 3±1ºC for 72h, simulating retail conditions. After this period, exudate was discarded and the samples were weighed in an analytical scale. Drip loss was calculated as initial weight minus final weight, and expressed as a percentage.

Water holding capacity was evaluated using a method adapted from Hamm (1960), based on meat water loss when pressure is applied on the muscle. Meat cubes weighing 2g were laid between two filter paper circles placed on glass plates, on which a 10kg weight was put for 5min. Samples were then removed from the

filter papers, and weighed. Water loss was calculated as the weight difference between initial and final weight. Results were expressed as the percentage of drip loss relative to initial sample weight.

Cooking loss was determined in intact breast fillet samples in triplicate 24h post mortem. Samples were weighed, placed in plastic bags and cooked in boiling water (82-85ºC) for 10min, and then allowed to cool (40ºC) on absorbent paper at room temperature. Samples were subsequently weighed, and the difference between initial weight (fresh breast fillet) and final weight (cooked breast fillet) corresponded to cooking loss (adapted from Honikel, 1987).

Shear force was measured in the samples used in cooking loss determination. Three samples per breast, measuring 2 x 2 x 1cm, were cut and placed, with the muscle fibers longitudinally oriented to the blades, in a Warner-Bratzler apparatus, according to the technique described by Froning et al. (1978).

Data were submitted to analysis of variance (ANOVA) using SAS statistical package (SAS Institute, 1998). Means were compared by the test of Tukey at 5% de probability.

Normal and pale breast samples submitted to sensorial analysis were previously roasted in a bakery oven pre-heated to 170°C. A panel of 30 non-trained tasters used descriptive tests using a 9-score hedonic scale to evaluate the following attributes: flavor, texture, preference, and general aspect. The 9 scores of the scale were 1 (extremely disliked), 2 (disliked very much), 3 (disliked), 4 (slightly disliked), 5 (indifferent), 6 (slightly liked), 7 (liked), 8 (liked very much), and 9 (extremely liked). The obtained data were relative to two meat types (pale and normal), each with 30 replicates, and each chicken breast was considered as one replicate. Results were submitted to analysis of variance (ANOVA) using SAS statistical package (SAS Institute, 1998). Means were compared by the F test.

RESULTS AND DISCUSSION

Figure 1 shows the incidence of PSE meat surveyed in the municipality of Dourados, MS, Brazil. Out of the 500 analyzed samples from the processing plant, 51 presented L*≥49. This high PSE incidence (10.20%) may be due to the fact that the survey was carried out during a day when the environmental temperatures were relatively high. This result is within the range observed by Owens et al. (2000), Woelfel et al. (2002), Woelfel & Sams (2001), Barbut (1998), and Vimini (1996), who observed 2 to 50% PSE incidence in chicken breast fillets, depending on environmental conditions. However, the incidence observed in the present experiment is lower than that found by Lara (2003), who evaluated PSE percentage in the meat of broilers submitted to heat stress before slaughter and obtained incidences of 35.30% in non-stressed and 37.08% in heat-stressed birds.

Some authors reported a significant effect of environmental temperature on PSE meat incidence (Owens et al., 2000; Guarnieri et al., 2002). During hot days, however, the application of preventive measures, such as the use of fans, foggers, and spray may significantly reduce the incidence of PSE meat (Komiyama, 2006).

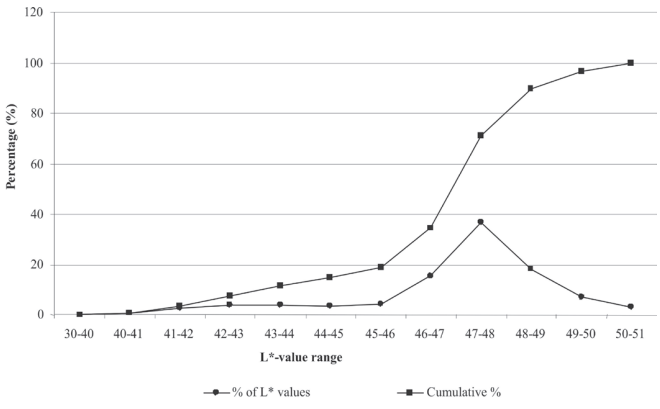

Figure 1 - L* values of breast fillets of broilers produced in Dourados, MS, Brazil.

Table 1 shows the results of evaluated meat parameters, including pH, lightness (L*), redness (a*), yellowness (b*), drip loss, cooking loss, shear force, and water holding capacity.

These results show that L* values of both PSE and normal breast fillets, from slaughter until 24h post mortem, increased, indicating that the meat became lighter during the process of transformation of muscle into meat, including after the establishment of rigor mortis. The higher L* value ($p \leq 0.05$) in the pale breasts in all evaluated periods characterize them as PSE meat. On the other hand, normal fillets presented higher a* values (redness) as compared to pale fillets. There was no difference in b* values (yellowness) between fillet types; however, b* values reduced with time, including after the establishment of rigor mortis. The calculation of the a*/b* ratio 24h after slaughter showed that normal fillets presented higher ratios (0.766) than pale fillets (0.502).

Table 1 - Meat quality characteristics of chicken breast fillets classified as PSE or normal.

Parameters	Meat classification		CV (%)
	PSE	Normal	
pH 2h post mortem	6.54	6.50	2.74
pH 4h post mortem	5.71b	6.00a	2.83
pH 24h post mortem	5.67b	5.89a	2.54
L* - initial	49.91a	45.22b	4.30
L* 4h	51.61a	46.34b	4.58
L* 24h	52.53a	47.38b	4.12
a* - initial	2.07b	3.34a	19.27
a* 4h	2.56b	3.76a	20.10
a* 24h	2.42b	3.78a	19.76
b* - initial	8.39	8.73	30.15
b* 4h	5.74	5.42	31.14
b* 24h	4.82	4.93	30.19
DL (%)	2.62a	1.37b	37.11
WHC (%)	68.88a	64.79b	8.14
CL (%)	22.78a	19.45b	19.26
SF (kgf/cm^2)	4.12	4.89	28.19

L*= lightness; a*= redness; b*= yellowness; DL= drip loss; WHC= water holding capacity; CL= cooking loss; SF= shear force. Means followed by different letters in the same row are significantly different by the test of Tukey (p<0.05).

L* value is the main parameter that determines poultry meat color. The optimal lightness range of chicken and turkey fillets is around 49-50 (Barbut, 1997). Higher values indicate lighter color, indicating that fillets have low pH (pH<5.6), whereas values below that range indicated that fillets are darker and have high pH (pH>5.9). In addition to L* values, the meat industry and researchers commonly use the a*/b* ratio.

Color is one of the main indicators of the quality of most foods. This sensorial quality has a high influence of the meat purchase decision and its acceptance by consumers. It is an important functional quality and it is closely related to other qualities, such as pH, water holding capacity, emulsifying capacity, and texture. In most cases, color can be considered as an indicator of these properties, which together, will affect consumer behavior, and will determine handling characteristics, tenderness, juiciness, aspect, yield, and cost of meat products.

Despite the initial color difference between normal and PSE fillet, initial pH was not different, but pale meat acidified faster, resulting in lower pH values at 4h and 24h post mortem (p≤0.05), which is explained by the acceleration of glycolysis post mortem in PSE meat (Komiyama, 2006). The combination of low pH and high temperature - as the muscle temperature is still close to its physiological temperature - in PSE meat causes higher denaturation of myofibrillar proteins. The pH of PSE meat is very close to the isoelectric point of myofibrillar proteins, and consequently, as these proteins have a similar amount of positive and negative charges, there is maximum approximation of thick and thin filaments. This causes the space between filaments to reduce or event to disappear, preventing these molecules to bind with water, reducing the muscle water holding capacity and stability. The water outside the muscle cells and their extremely closed protein structure reflect the incident light, making PSE meat extremely pale (Rosenvold & Andersen, 2001).

PSE fillets presented higher drip loss and cooking loss (p≤0.05) relative to normal fillets, which presented higher water holding capacity (p≤0.05). There was no significant difference in shear force (p>0.05) between the two fillet types. The most serious defect of PSE meat is drip loss. In this type of meat, water is not closely bound to proteins, and cell membranes are very permeable. The cause of drip loss is protein denaturation (Rosenvold & Andersen, 2001). Woelfel et al. (1998) evaluated PSE incidence in chicken meat in a commercial processing plant and found that approximately 37% of the 1,751 examined breast fillets were classified as pale or showed poor water holding capacity. In a more recent study, Woelfel et al. (2002) found 47% of pale fillets out of a total of 3,554 fillets evaluated in a commercial processing plant that could be potentially classified as PSE, and also observed they presented low water holding capacity.

Table 2 shows the results of the sensorial analysis of pale and normal chicken breast fillets. No significant differences (p>0.05) were detected between fillets as to flavor, tenderness, preference, or general aspect. These results are consistent with those described by Komiyama (2006), who also did not describe significant differences in the sensorial attributes of PSE breast fillets as compared to normal fillets. Changes in meat products may be caused by oxidation reactions, and subsequent breakdown of oxidation products, which is characteristic of PSE meat (Komiyama, 2006).

Table 2 - Sensorial analysis of chicken breast fillet with PSE and normal characteristics in Dourados, MS, Brazil.

Treat.	Evaluated parameters			
	Flavor	Tenderness	Preference	Aspect
Normal	7.00	6.25	6.84	7.80
PSE	6.12	6.78	6.15	6.00
CV (%)	22.58	27.12	24.15	20.19
F test	3.12ns	1.27ns	1.19ns	1.50ns
SD	1.18	1.62	1.49	1.13

There were no significant differences (p>0.05) among means as analyzed by the F test. SD: standard deviation.

Sensorial characteristics, such as color, texture, firmness, and tenderness after cooking, partially depend on water holding capacity. However, the differences in the functional properties of PSE meat observed in the

present study did not change the sensorial quality of the evaluated samples.

CONCLUSIONS

Despite the significant changes observed in meat physical properties in PSE breast fillets, these were not perceived by the consumers in terms of tenderness, aspect, and flavor.

The incidence of PSE meat found in the present study may cause losses to the processing industry due to its low water holding capacity.

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