



Effect of Deboning Time on the Quality of Broiler Breast Meat (*Pectoralis Major*)

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■ Keywords

Broiler chickens, deboning time, meat quality, R value, shear force

■ Acknowledgements

The authors thank Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for financial support.

ABSTRACT

The present study evaluated the effect of different deboning times on the quality of broiler breast meat. Seventy-two broiler breasts were evaluated. They were distributed in a completely randomized experimental design, with six treatments, six repetitions and two birds per parcel. The treatments were denominated as follows: A - deboning immediately after chilling, B - deboning 1 h after chilling, C - deboning 2 h after chilling, D - deboning 3 h after chilling, E - deboning 4 h after chilling, and F - deboning 24 hours after chilling. Lowest pH values ($p < 0.05$) were seen when deboning was performed 24 h after carcass chilling ($pH = 6.00$) in comparison to deboning at 0 h (6.69) and 1 h (6.42) after chilling. R values were inversely proportional to pH values, *i.e.*, R values were lower ($p < 0.05$) in treatments A (1.05) and B (1.07) when compared to treatment F (1.44). No differences were seen in cooking loss during thermal treatment (broiling) of the muscle *P. major*. Higher shear forces ($p < 0.05$) were seen in broiled muscles from carcasses with shorter storage times (A - 11.78 kgf and B - 10.75 kgf) before deboning, when compared to treatments E (6.11 kgf) and F (5.64 kgf). Higher L^* values were observed in the treatment in which carcass deboning was performed 24 hours after chilling (49.26) in comparison to deboning immediately after chilling (44.68). Therefore, it was concluded that an interval of at least 4 hours is needed between chilling and deboning to obtain broiled breast fillets with tender texture. Furthermore, paler meat color (L^* value) was produced with longer carcass storage before deboning.

INTRODUCTION

The increasing demand for easily cooking products with high quality and at reasonable prices has caused changes in broiler production systems. The market for chicken parts is nowadays one of the fastest growing segments of the food industry worldwide. According to Seabra *et al.*, (2001), special interest in this area is partially due to the convenience and nutritional value of cuts such as chicken breasts and thighs.

It is known that many factors influence final tenderness in broiler meat, among which pre-slaughter factors (Beraquet, 1999) and post-slaughter factors, such as techniques of electrical stimulation and muscle tensioning (Thompson *et al.*, 1987; Cason *et al.*, 1997; Veeramuthu & Sams, 1999), meat storage conditions (Ventura *et al.*, 2001), thermal treatment (Galvão, 2003) and *post-mortem* deboning time (Lyon *et al.*, 1998).

According to Lyon *et al.*, (1998) the early harvest of meat from carcasses has raised some concern about texture and juiciness characteristics of filets and other types of breaded chicken portions.



Toughness of cooked broiler breast meat continues to be a problem for processors, and postchill deboning time is the most significant factor on the ultimate texture of intact breast meat.

Castillo & Custódio (2002) described that muscles deboned during early *post-mortem* period still have energy available for contraction and become rigid if harvested. Thus, 50 to 80% of the meat that was deboned early (0 to 2 hours *post-mortem*) became rigid. On the other hand, 70 to 80% of the meat was tender if deboning was performed after an interval of 6 hours, however, this is costly for processors (time, space and energy requirements).

The poultry industry has recently introduced electrical stimulation immediately after death to hasten *rigor mortis* development of carcasses and reduce aging time before deboning. Such treatment after death results in tender deboned poultry meat within two hours *post-mortem* instead of the usual aging times of four to six hours. However, electrical stimulation is still being developed and optimized.

In face of such considerations, the objective of the present study was to evaluate the influence of different deboning times on the quality of broiler breast meat.

MATERIAL AND METHODS

Location

The experiment was conducted in a commercial abattoir at Pirangi County (SP), a city located at approximately 50 km from Jaboticabal (SP, Brazil). Analyses were conducted at Laboratório de Tecnologia dos Produtos de Origem Animal from the Departamento de Tecnologia, at Faculdade de Ciências Agrárias e Veterinárias - UNESP, Câmpus de Jaboticabal.

Biological material and Abattoir Procedures

Slaughter was performed according to the abattoir's ability to provide birds from a single producer, so that homogeneous birds (Cobb strain, 42-day-old males weighing 2.3 kg of final body weight) and similar conditions of harvesting, transportation and slaughter of birds could be obtained.

Breasts were taken from all of the birds. After a period of feed withdrawal (6 hours) 72 birds were slaughtered following standard procedures: stunning (7 s), bleeding (2 min), scalding for 2.5 min at 54°C, defeathering, eviscerating, pre-chilling in water at 20°C for 20 min, chilling at 4°C for 25 min, and dripping

for 3 min. After dripping, carcasses were placed into plastic bags and kept on ice until deboning (harvesting of both *Pectoralis major*). Following deboning, the muscles were packaged, identified and replaced on ice until analysis, *i.e.*, 24 hours after chilling.

Experimental Diets

Birds were given feed and water *ad libitum* throughout the experimental period, which was divided in three phases. Initial diets (1-21 days) contained 2,944 kcal/kg of metabolizable energy (ME), 23% of crude protein (CP), 1.285% lysine (Lys), 0.537% methionine (Met), 1.001% Calcium (Ca) and 0.481% available Phosphorus (P). Growing diet levels (22-35 days) were 3,100 kcal ME /kg, 20% CP, 1.074% Lys, 0.388% Met, 0.913% Ca and 0.377% available P, and finishing diets (36-42 days) contained 3,200 kcal ME /kg, 18% CP, 0.935% Lys, 0.333% Met, 0.803% Ca and 0.327% available P. Other nutrient levels were according to those recommended by NRC (1994).

Experimental Design and Treatments

A completely randomized experimental design was used, with 6 treatments, 6 repetitions and two birds per parcel (72 broiler breasts). Treatments were: A - deboning immediately after chilling, B - deboning one hour after chilling, C - deboning 2 hours after chilling, D - deboning 3 hours after chilling, E - deboning 4 hours after chilling and F - deboning 24 hours after chilling.

Repetitions were processed separately, that is, one at each week (12 birds/treatment/week). Such scheme was followed because it was not possible to debone more than one repetition at the planned intervals. Time intervals were rigorously followed in each treatment; otherwise, the proposed objectives would not be appropriately achieved.

Evaluated Parameters

The central part of each half breast was used as standard to perform physicochemical analyses. Carcasses and deboned breasts were packaged, identified and replaced on ice until analysis.

- pH

Raw meat pH was evaluated (in the same place) at deboning and 24 hours after chilling using a portable pHmeter (model IpHPJ, Jonhis).

- Ratio value (R value)

In order to determine the R value, samples were collected at deboning (0, 1, 2, 3, 4 hours) and 24 hours



after chilling. All samples were immediately frozen in liquid nitrogen. Measurements were made in duplicates, according to the methodology proposed by Honikel & Fisher (1977). Briefly, nucleotides were extracted from 2-g samples by homogenization for 30 s (Waring Blender homogenizer) in 1 M perchloric acid (1:10 w/v). The homogenate was then filtered and centrifuged for 5 min at 3,000 g (Centrifuge Excelsa II, model 206MP). One aliquot (0.1 ml) of the supernatant was diluted in 4.9 ml of 0.1 M phosphate buffer pH 7.0. Absorbance was determined at 250 nm and 260 nm with a spectrophotometer (Hitachi M V-200), using phosphate buffer as reference. The R value corresponds to the ratio between the concentration of adenine phosphatidyl compounds (ATP, ADP, AMP and others) and the concentration of a major breakdown product, inosine monophosphate (IMP). It was calculated as the ratio between the absorbance at 250 nm (IMP) and the absorbance at 260 nm (ATP), and serves as a good monitor of ATP depletion.

- Cooking Losses

Crude breast muscle samples were weighed and put in trays with aluminum grills previously dried in an incubator. The trays were placed inside the oven until the core temperature of the samples was 80°C. The samples were then cooled at room temperature; re-weighed and cooking loss was calculated as the difference between the initial and the final weight of the sample.

- Shear Force

The samples used for cooking loss were also used to evaluate shearing force according to the methodology proposed by Froning & Uijttenboogaart (1988). The samples were placed in the Texture Analyzer TA-XT2i, calibrated with standard weight (5 kg) and blade descent speed of 5 m/s. Fibers were oriented perpendicularly to the Warner-Bratzler blade.

- Color

Raw meat color was determined using a CR-200 Minolta colorimeter. Three measurements were made at deboning and 24 hours after chilling. Obtained values were expressed in L*, a*, b* (Cielab system), so that L* indicates lightness, a* redness and b* yellowness of the meat.

Statistical Analysis

Analysis of variance was performed using the software Estat 2.0 (1992) and differences between

treatment means were evaluated by Tukey's Test at a significance level of 5 % ($p < 0.05$).

RESULTS AND DISCUSSION

Results of pH and R values measured in broiler breast muscle are shown in Table 1. There were no differences among mean pH values of *Pectoralis major* muscles harvested immediately after chilling or deboned 1, 2, 3 and 4 hours after chilling. Nevertheless, means from treatment F were significantly ($p < 0.05$) different from treatments A and B. Such results partially corroborate the findings reported by Lyon *et al.* (1985), who observed significantly higher pH levels in muscles deboned immediately after chilling compared with muscles deboned at 1, 2, 4, 6, 8 or 24 hours after chilling. On the other hand, Sams *et al.* (1990) reported no significant differences among the final pH of breast muscles submitted to deboning after defeathering (hot or pre-rigor deboning), after chilling or after 24 hours of carcass storage. The present study has not clearly evidenced until when the pH decrease is accentuated. Nevertheless, data reported herein agree with the *post-mortem* acidification process that is attributed to the accumulation of lactic acid in the muscle (final product of anaerobic metabolism) (Sams, 1999). However, higher pH values (6.0) were reported in the present study in comparison to those reported by Pearson (1994) (5.3 to 5.8), suggesting that these birds were probably stressed when they were killed.

Table 1 - pH and Ratio values measured in *Pectoralis major* breast muscle at deboning and 24 hours after chilling

Evaluated Parameter	pH		Ratio Value	
	At deboning	24 h after	At deboning	24 h after
A	6.69 ^a	5.90	1.05 ^b	1.49
B	6.42 ^a	6.00	1.07 ^b	1.48
C	6.37 ^{ab}	5.94	1.12 ^b	1.49
D	6.33 ^{ab}	5.91	1.25 ^{ab}	1.50
E	6.37 ^{ab}	5.94	1.36 ^a	1.53
F	6.00 ^b	6.00	1.44 ^a	1.44
CV (%)	3.74	3.14	9.61	9.72
SEM	0.097	0.076	0.047	0.059

a,b - means followed by different letters within columns are different ($p < 0.05$) by Tukey's test. A - deboning immediately after chilling, B - deboning 1h after chilling, C - deboning 2h after chilling, D - deboning 3h after chilling, E - deboning 4h after chilling, F - deboning 24h after chilling.

Treatments showed similar pH values 24 hours after chilling. Similarly, Stewart & Fletcher (1984) also reported that the faster or slower rate at which *post-mortem* muscle pH changed had no effect on final pH. In other words, the differences in pH decrease were



only temporary in muscle samples submitted to different treatments.

According to Honikel & Fisher (1977) pre-*rigor* muscles have high concentrations of nucleotides that contain adenine and the R value is low; while *rigor mortis* proceeds, the R value increases. Such information is pertinent, since Table 1 shows that increasing R values were obtained with longer intervals between chilling and deboning. Although such variation was not significant between consecutive intervals, it is evident that a storage period of at least 4 hours is necessary so that the values become stable, *i.e.*, so that R values are not significantly different from muscles that are harvested 24 hours after chilling. As it has already been described, results from treatment F indicate when R values reach a plateau or, in other words, the lowest concentration of ATP that causes minimal muscle contraction.

As show in Table 1, the treatments had no influence on final R value (24 hours after chilling). Similarly, Thompsom *et al.* (1987) evaluated carcass electrical stimulation for different periods and reported no treatment effects on final R value.

Table 2 shows that there was no influence of treatments on cooking loss of muscle *P. major* after broiling. These findings corroborate results reported by Lyon & Lyon (1992), who found no differences in liquid loss during the thermal treatment when storage intervals of 0, 1 and 24 hours of the whole carcass were used before deboning was performed. According to Dransfield & Sosnicki (1999), the probability of obtaining meat with lower water holding capacity increases with the development of *rigor mortis*, and consequently product quality decreases. Nevertheless, this was not observed in the present study.

Data of shear force (SF) are presented in Table 2. For broiled muscles, treatments A and B were similar and produced fillets with higher resistance to cut, *i.e.*, tougher meat. Such results corroborate those reported by Lyon *et al.* (1985), in which muscles deboned just after chilling showed higher shear force when compared to other treatments. Additionally, Craig *et al.* (1999) reported higher SF (8.9 kgf/g) in breasts deboned 2 hours after slaughter when compared to breasts submitted to electrical stimulation (6.5 kgf/g). According to Castillo & Custódio (2002), *rigor* frequently develops in birds from 0.5 to 4 hours after the death. Thus, meat cuts with high SF would be produced if harvested from the carcass during the *rigor* process. Such observation agrees with the results reported herein, since higher SF was seen in the treatments in which deboning was performed prematurely in the process of *rigor*.

No differences were seen between treatments E and F, which produced muscle with more tenderness (6.11 and 5.64 kgf). According to Lyon & Lyon (1990) and Papinaho & Fletcher (1996), SF values close to 6.0 kgf are usually considered as moderately tender to tender. Therefore, theoretically, whole carcasses should be submitted to refrigeration for a minimal period of 4 hours before muscle harvesting, in order to produce broiled breast fillets with relatively tender texture. Lyon & Lyon (1998) reported that broiler breasts deboned and cooked 6 hours after storage showed SF values significantly smaller (6.21 kg) when compared to 2 h of storage (10.39 kg). Northcutt *et al.* (2001) evaluated slaughter age and the correlation with deboning time and gender on breast meat tenderness. Independent of slaughter age, fillets deboned immediately after slaughter were classified as very tough (12.6 kgf) and fillets deboned 4 or 6 hours after slaughter were classified as moderately tender and tender (6.61 to 3.61).

Treatments influenced ($p < 0.05$) L* and a* values of *P. major* muscle (Table 3). Longer intervals before deboning led to a significant increase in meat lightness (44.68 to 49.26). The L* value was not different between treatments A and D, but both presented slightly darker muscle when compared to treatment F. The low brightness observed in treatments A and B can be correlated to the high final pH observed and, according Forrest *et al.* (1979), the higher the pH values, the darker is the produced meat. Differences in L* values were not seen if measured exactly at 24 hours after chilling.

Treatment D presented meat with higher ($p < 0.05$) value of a* when compared to treatments A, B and F.

Table 2 - Cooking loss and shear force values of Pectoralis major breast muscle obtained after thermal treatment of broiled breast muscle.

Evaluated Parameter	Cooking Loss (%)	Shear Force (kgf)
A	30.80	11.78 ^a
B	32.80	10.75 ^a
C	29.30	9.38 ^{ab}
D	29.70	8.47 ^{ab}
E	29.30	6.11 ^b
F	30.80	5.64 ^b
CV (%)	21.59	29.84
SEM	2.683	1.058

a,b - means followed by different letters within the column are different ($p < 0.05$) by Tukey's test. A - deboning immediately after chilling, B - deboning 1h after chilling, C - deboning 2h after chilling, D - deboning 3h after chilling, E - deboning 4h after chilling, F - deboning 24h after chilling.



According Castillo & Custódio (2002) high myoglobin concentration in muscle may indicate pre-slaughter stress and excitation of the birds; however, high values were not seen 24 hours after chilling.

Table 3 - Lightness (L* value), redness (a* value) and yellowness (b* value) measured in *Pectoralis major* muscle at deboning and 24 hours after chilling

Evaluated Parameters	Color (At deboning)					F	CV (%)	SEM
	A	B	C	D	E			
L*	44.68 ^b	45.88 ^{ab}	47.01 ^{ab}	44.42 ^b	47.67 ^{ab}	49.26 ^a	5.22	0.989
a*	3.65 ^b	3.73 ^b	4.46 ^{ab}	4.76 ^a	4.02 ^{ab}	3.74 ^b	14.04	0.232
b*	6.20	4.40	6.43	4.67	4.64	4.95	29.28	0.623

Color (24 hours after chilling)								
L*	47.96	48.12	45.57	46.70	48.23	49.26	5.30	1.031
a*	3.34	3.12	4.15	3.58	3.54	3.74	21.02	0.307
b*	3.99	3.09	4.02	3.44	4.68	4.95	38.68	0.636

a,b – for each independent time, means followed by different letters within the row are different (p<0.05) by Tukey's test. A - deboning immediately after chilling, B - deboning 1h after chilling, C - deboning 2h after chilling, D - deboning 3h after chilling, E - deboning 4h after chilling, F - deboning 24 h after chilling.

There were no color differences at 24 h, probably because meat lightness and redness changed concomitantly to pH decrease, i.e., whereas pH values were unstable. Nevertheless, after the pH had stabilized (24h), color at the different deboning times showed no significant differences as well. It was also observed that L* values at 24 h were higher and a* values at 24 h were lower than L* and a* values at deboning. These findings corroborate results described by Forrest *et al.* (1979), where meat was darker at higher pH values, and the opposite was also true.

CONCLUSIONS

Results indicated that a minimum of 4 hours is required between chilling and deboning in order to obtain broiled breast filets with tender texture. Furthermore, paler meat color (L* value) was produced with longer carcass storage before deboning.

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