CHAPTER 3

EXPERIMENT 1

Broiler Breast Enhancement through the Utilization of Chicken Collagen in a Chunked and Formed Deli Roll

3.1 ABSTRACT

A randomized complete block design with four treatments (100% pale, soft, and exudative (PSE), 100% PSE + 1.5% chicken collagen, 100% normal, and 100% normal + 1.5% chicken collagen) and six replications was utilized to test the effects of raw material and chicken collagen on protein functionality in the formulation of chunked and formed broiler breast. Addition of 1.5 % chicken collagen decreased ($p < 0.05$) the cooking and chilling loss of PSE and normal deli rolls, thus demonstrating it's potential to improve moisture retention. Inclusion of chicken collagen also increased ($p < 0.05$) protein bind in the PSE deli rolls so that it was not different ($p > 0.05$) from normal rolls without collagen. This research demonstrated that enhancement of broiler breast with chicken collagen has the potential to add value to broiler breast deli rolls manufactured from PSE and normal raw material through the improvement of water holding capacity and protein binding.

Key Words: PSE; chicken collagen; chunked and formed; water holding capacity; protein binding

3.2 INTRODUCTION

Increased consumer demand for poultry has lead to breeding broilers that reach slaughter weight faster at a younger age as well as with shortened processing times. Although successful in production, these practices have lead to growth defects and rapid chilling regimes that contribute to the production of pale, soft, and exudative (PSE) poultry (Alvarado and Sams, 2003). Though similar to the PSE condition that is evident in pork, significantly less research has been completed on PSE poultry. Combinations of a stressful atmosphere, mutations in genetic lineages and increased movement through the slaughter process all contribute to the occurrence of PSE, yet a rapid decrease in the pH level of high temperature carcasses is a direct cause of PSE poultry (Fernandez et al., 1994).

Rapid glycolysis, responsible for rapid pH decline, is capable of denaturing the muscle proteins related to color, texture, and water-holding capacity. Although PSE meat is initially observed in the fresh state, further processed products made with PSE have poor texture and are exudative. Products processed from PSE meat also exhibit reduced cohesiveness or cracking, which is the consequence of denatured proteins in the raw material (Solomon et al, 1998). Enhanced usability of PSE meat would add value to this low quality raw material as well as locate a niche for PSE raw material that is currently sold in the fresh state (McKee and Sams, 1998). Barbut (1997) reported that the occurrence of PSE meat in broiler chickens ranged from 0 to 28% in seven different flocks. In a grocery store survey of 1,000 boneless, skinless, broiler breast fillet packages, approximately 7% had one or more fillets that were significantly darker or lighter than the other fillets in the same package (Fletcher, 1999).

To use PSE meat, protein functionality must be increased to improve the texture, color, and water retention characteristics so that they are similar to normal meat. Incorporating more

moisture into a product provides improved yield for the processor and has resulted in a tender, juicier product for the consumer (Smith and Acton, 2001). Practices such as tumbling raw meat in a solution of water, salt, phosphate and collagen improve moisture retention and color characteristics with an overall improvement of texture. Currently, marination utilizing different systems and ingredients is being investigated in an effort to improve the moisture, bind, and texture of less tender poultry.

Collagen is the predominant connective tissue comprising of 3-6% of the total protein in poultry muscle tissue (Smith, 2001). Collagen is located in tendons, skin, and bone, and can be very influential on the effects of processed meats. Collagen can be converted to gelatin by heating with added water. This causes formation of a gel, and improves product yield, texture, and palatability (Osburn and Mandigo, 1998). Previous research has demonstrated that the incorporation of pork collagen improves the water-holding capacity and texture of PSE pork in boneless deli ham (Schilling et al., 2003, 2004). When utilized in meat and poultry products, collagen has the ability to increase fat, water, and protein binding since the protein matrix provides a stable structure by immobilizing free water and preventing moisture loss during heat processing and storage (Prabhu, et al., 2002). The objective of this research was to examine the quality effects of adding chicken collagen to PSE and normal broiler meat in the formulation of a restructured product.

3.3 MATERIALS AND METHODS

3.3.1 Broiler Breast Raw Materials

Broiler breasts were obtained from a commercial poultry processing plant in Virginia from market age broilers at 24-48 hours postmortem. PSE and normal broilers breasts were selected based on CIE L* values utilizing a chroma meter (Model CR-200, Minolta Camera Co., Ltd., Osaka Japan). Following calibration (white plate, No. 20933026; CIE L* 97.91, a* -0.70, b* +2.44, Minolta Camera Co., Ltd., Osaka Japan), CIE *L values were taken in three similar locations on the inside of the breast. To reduce variation, PSE samples with a CIE L* value >55 and normal samples with a CIE L* value of <50 were utilized (Barbut, 1993).

After arriving in the laboratory, pH was measured to ensure proper selection of samples. pH was measured for the individual samples with a portable pH meter (Model IQ150, IQ Scientific Instruments, Inc., San Diego, CA). Only pale samples with a pH below 5.8 and normal samples with a pH above 5.8 were utilized in the study. Once evaluated for pH, the broiler breasts were packaged in 15.2 x 20.3 cm, 3-mil high performance bags (KOCH Supplies, Inc., Model FreshPak Vacuum Pouches, Kansas City, MO), sealed with a vacuum (88 kPa) packaging machine (KOCH Supplies Inc., Model Nirovac X 180 Digi-gas, Kansas City MO), and stored in a cooler (4°C).

3.3.2 Treatment Combinations

Broiler breast treatments consisted of 100% PSE, 100% PSE + 1.5% chicken collagen (Model C5501, Proliant, Ames, IA), 100% normal, and 100% normal + 1.5% chicken collagen (Model C5501, Proliant, Ames, IA).

3.3.3 Sample Processing

Samples were trimmed of external fat and bone and cut into 2.5 cm by 2.5 cm cubes. Several samples were combined for a 0.908 kg treatment. A marinade solution of 22% water on a meat weight basis (MWB), 0.5% phosphate on a finished product basis (FPB), and 1.0% salt on a finished product basis (FPB) was utilized. Each treatment was placed in a 20-liter tumbler (Model Inject Star MC 20/40/60/80-226, Globus, Austria) and the brine was evenly distributed inside the tumbler. Chicken collagen was incorporated as a dry mixture and evenly distributed over the brine and chicken cubes.

The treatments were then individually tumbled (20 rpm) under vacuum (72.7 kPa) at 4°C for 1.5 h, stopping after each 15 min tumble for 10 min rest to increase brine absorption. After tumbling each treatment was manually stuffed into a 4.5 diameter cellulose casing (Model Reg Fib CSG 5*25 Light PS, Viskase, Chicago, IL), sealed (Model PRA65L, Tipper Tie, Apex, NC), and stored in a 4° C cooler until all treatments were completed.

Following completion of each replication, individual treatments were weighed and heat processed in an Alkar smokehouse (Model 1000, Alkar, Lodi, WI). The smokehouse schedule was 0.5 h at dry bulb 54˚C and no wet bulb, 2 h at dry bulb 66˚C and wet bulb 47˚C, 1 h at dry bulb 77˚C and wet bulb 59˚C, and approximately 2 h at dry bulb 85˚C and wet bulb 69˚C. Two randomly selected turkey rolls were used for endpoint temperature determination. The boneless deli breast rolls were immediately cold showered for 15 min and then placed in a meat lug (Model 3502 58961, Koch Equipment LLC, Kansas City, MO) and stored at 4˚C cooler. Following a storage time of 8-12 h, 12.7 mm slices were manually cut, vacuum packaged (88 kPa), and stored in a 4˚C cooler for cooked color, protein bind, and moisture loss determination.

3.3.4 Cooking and Chilling Loss

Individual broiler breast rolls were weighed prior and 8-12 hrs after heat processing to determine cooking and chilling loss. Cooking and chilling loss was calculated as [(raw weight-cooked weight)/raw weight] x 100 and reported as a percentage.

3.3.5 Expressible Moisture

The Instron Universal Testing machine (Model 1011, Instron Corp., Canton, MA) was utilized to determine expressible moisture. Two randomly selected slices (12.7 mm) from each treatment were analyzed and four cores (19 mm diameter) were taken from each 12.7 mm slice. The cores were individually weighed and then placed between two 12.5 cm Whatman #1 filter papers to absorb excess moisture. Cores were axially compressed to a height of 4.75 mm (75% compression) and held for 15 s once the deformation point was reached. After removal of the force, the core was reweighed. The Instron was programmed with a 500 kg compression load cell and a crosshead speed of 100 mm/min. Expressible moisture was expressed as a percentage: [(initial wt – final wt)/initial wt)] x 100.

3.3.6 Purge Loss

Two randomly selected slices from each treatment were weighed, individually packaged in 15.2 x 20.3 cm, 3-mil high performance bags (KOCH Supplies, Inc., Model FreshPak Vacuum Pouches, Kansas City, MO), and sealed under vacuum (88 kPa) with a vacuum packaging machine (KOCH Supplies Inc., Model Nirovac X 180 Digi-gas, Kansas City MO) prior to 48 h storage (4°C). After storage, the residual moisture was eliminated with a paper towel and individual slices were reweighed. Purge loss was reported as [(initial weight-final weight)/initial weight] x 100.

3.3.7 Total Moisture

Percentage moisture (39.1.02, AOAC, 1995) was measured in triplicate for each treatment in a convection oven (100-102˚C, 18-24 h, Blue M Electric Company, Model OV-490A-2, Blue Island, IL).

3.3.8 Protein Bind

Protein bind strength was evaluated using a procedure modified from Field et al., (1984) that utilizes the Instron Universal Testing machine (Model 1011, Instron Corp., Canton, MA). Three 12.7 mm slices were randomly selected from each treatment to make determinations. The Instron attachment (manufactured by the Department of Food Science and Technology, Virginia Polytechnic Institute & State University, Blacksburg, VA) used in the determination was composed of a 25.0 mm diameter steel ball (chrome alloy grade 25) probe and a sample holder. The Instron was set at a speed of 100 mm/min. The bind strength was reported as the peak force (kg) and total energy (kg/mm).

3.3.9 Cooked Color

Two randomly selected broiler breast slices from each treatment were used to evaluate cooked color. CIE L*, CIE a*, and CIE b*, were all measured using a chroma meter (Model CR-200, Minolta Camera Co. Ltd., Osaka Japan). Measurement was taken from three areas per 12.7 mm slice, and the chroma meter was calibrated using a standard calibration plate (white plate, No. 20933026; CIE L* 97.91, a* -0.70, b* +2.44) each time prior to testing.

3.3.10 Statistical Analysis

A randomized complete block design with six replications was utilized to test the treatment effects of chicken collagen, and raw material (SAS, 2001). Blocking reduced variation among replications caused by seasonal variation. When significant differences occurred for a

response (P< 0.05), Duncan's Multiple Range Test (Duncan, 1955) was performed to separate treatment means.

3.4 RESULTS AND DISCUSSION

3.4.1 Water-holding Capacity

Addition of collagen to 100 % PSE broiler breasts decreased (p<0.05) cooking and chilling loss (Fig. 3.1). PSE treatments with collagen were also similar (p>0.05) to normal treatments with and without collagen. Collagen addition seemed to complement the myofibrillar proteins, similar to Prabhu et al. (2000) who also improved cooking yield in coarse ground and finely comminuted sausage products by incorporating pork collagen. This increase in moisture retention may be due to collagen improving the functionality of the myofibrillar proteins and allowing them to bind more water. Sadowska et al. (1980) found improvements in moisture retention and suggested that water binding could be improved from the collagen-myofibrillar interactions. Schilling et al., (2003) also found that inclusion of collagen to PSE pork was successful in decreasing (p<0.05) cooking loss. Incorporation of collagen to normal broiler breasts did not decrease (p>0.05) cooking and chilling loss. This lack of difference between the normal treatments could be attributed to the normal broiler breasts having functional myofibrillar proteins and being able to adequately bind water.

No differences (p>0.05) were seen among treatments for expressible moisture, purge loss, and total moisture (Table 3.1). These results demonstrate that collagen was able to bind loosely bound water tight enough in the PSE samples to be similar (p>0.05) to the normal samples. This similarity could also be from selecting PSE that was severely pale and soft, but not exudative enough to detect differences from these measurements. Schilling et al., (2003) demonstrated decreased expressible moisture when 3 % pork collagen was utilized in PSE pork treatments

suggesting that a higher percentage of chicken collagen would have been more effective at binding loosely bound water from the PSE broiler. Incorporating a higher salt concentration in the formulation could have also increased the moisture retention of the PSE chicken.

3.4.2 Protein Bind

Texture analysis indicated that addition of collagen was effective at increasing the total energy and maximum peak force of 100% PSE treatments so that it is similar ($p>0.05$) to 100% normal treatment with and without collagen (Fig. 3.3, Table 3.1). Treatments formulated with 100% PSE, but no collagen recorded the lowest ($p<0.05$) total energy and protein bind values, demonstrating poor protein interaction and functionality. Collagen addition demonstrates that the inclusion of a functional protein to myofibrillar proteins may have the ability to improve protein interaction and strengthen the protein bind of a PSE product. Kenney et al. (1992) also demonstrated that connective tissue could improve tensile strength in restructured beef possibly due to collagen forming a gel that complemented muscle protein gelation. This is similar to the findings of Schilling et al. (2003) where pork collagen increased ($p<0.05$) the protein-protein bind of PSE pork. The addition of collagen to normal broiler breast was not successful ($p>0.05$) in increasing the protein-protein bind of normal broiler breast. This could be attributable to the normal broiler breasts having functional proteins that were able to adequately form a cohesive deli roll. Schilling et al. (2003) also found that normal pork did not improve in bind suggesting it was due to sufficient protein functionality of the normal pork.

3.4.3 Cooked Color

Addition of chicken collagen decreased the CIE L* and CIE a* values of PSE broiler breast treatments so that they were similar ($p>0.05$) to 100 % normal treatments with and without collagen (Table 3.1, Fig. 3.2). This suggests that the addition of collagen may be able to increase

the solubility of the sarcoplasmic proteins though extraction from the myofibrils of the PSE poultry, and decrease the lightness. PSE treatments with no collagen were paler ($p < 0.05$) than the normal treatments with added collagen, demonstrating poor sarcoplasmic protein functionality. In contrast, Schilling et al. (2003) reported that addition of collagen to 100 % PSE pork increased ($p < 0.05$) lightness compared to the control, suggesting that increased CIE $L*$ values may be due to the addition of light colored collagen to an already pale product.

No differences ($p > 0.05$) were seen among all treatments for CIE b* values (Table 3.1). PSE treatments without added collagen and normal treatments with added collagen recorded the highest ($p > 0.05$) CIE b* values and were almost identical. Schilling et al., (2003) noted a similar finding when pork collagen was added to PSE pork and suggested that this outcome could be attributed to a yellow adjunct being added to an initially pale product.

3.5 CONCLUSIONS

Chicken collagen was found to improve cooking and chilling loss, protein bind, and the CIE L* and CIE a* values of chunked and formed deli rolls formulated with PSE broiler breasts. Further investigation would be required to find the appropriate usage level for chicken collagen as well as the maximum allowable amount of PSE material.

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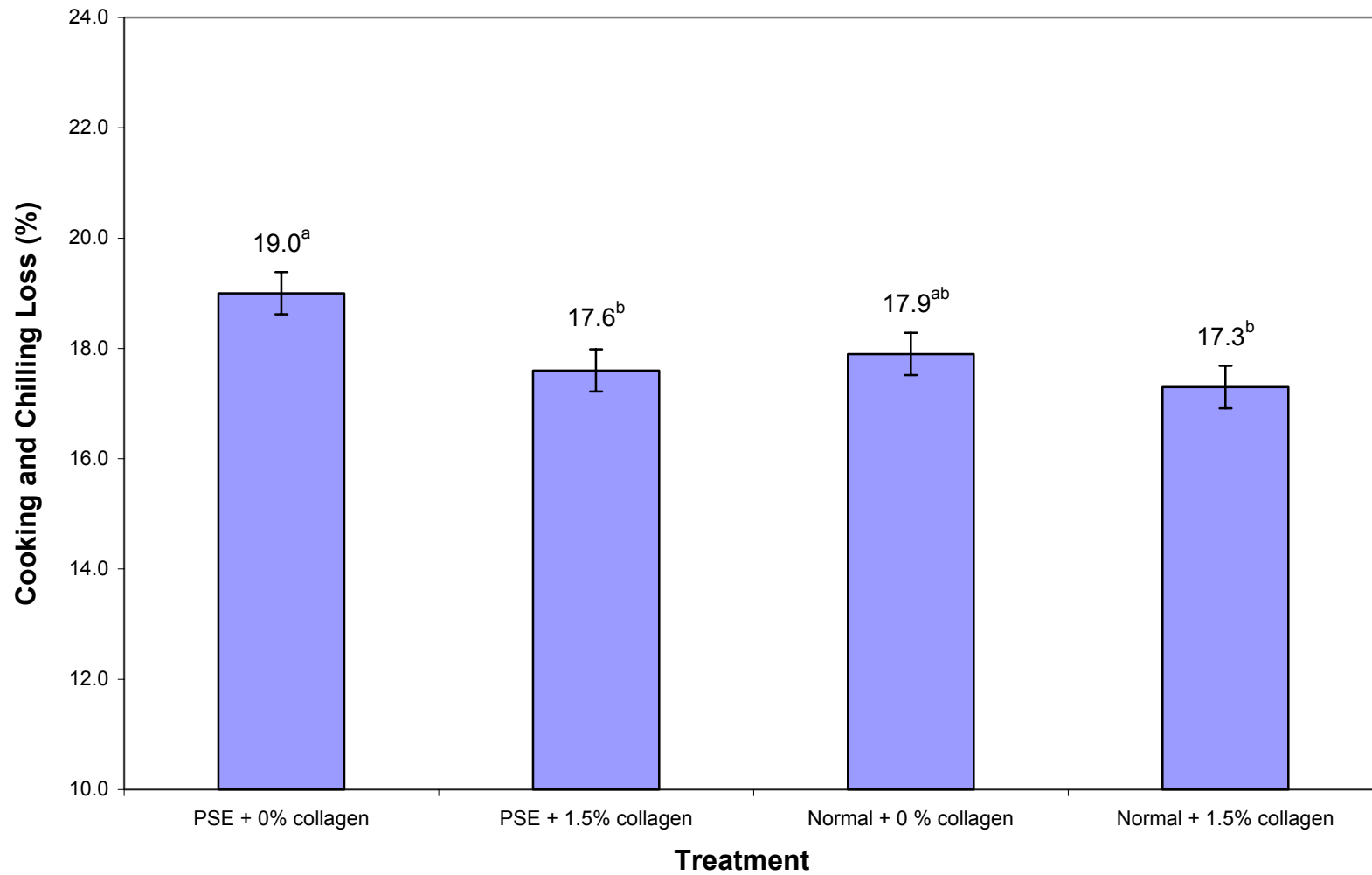
FIGURE 3.1: Effects of 0 or 1.5 % chicken collagen on the cooking and chilling loss of chunked and formed broiler breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different (p<0.05). Standard error bars are included for each treatment.
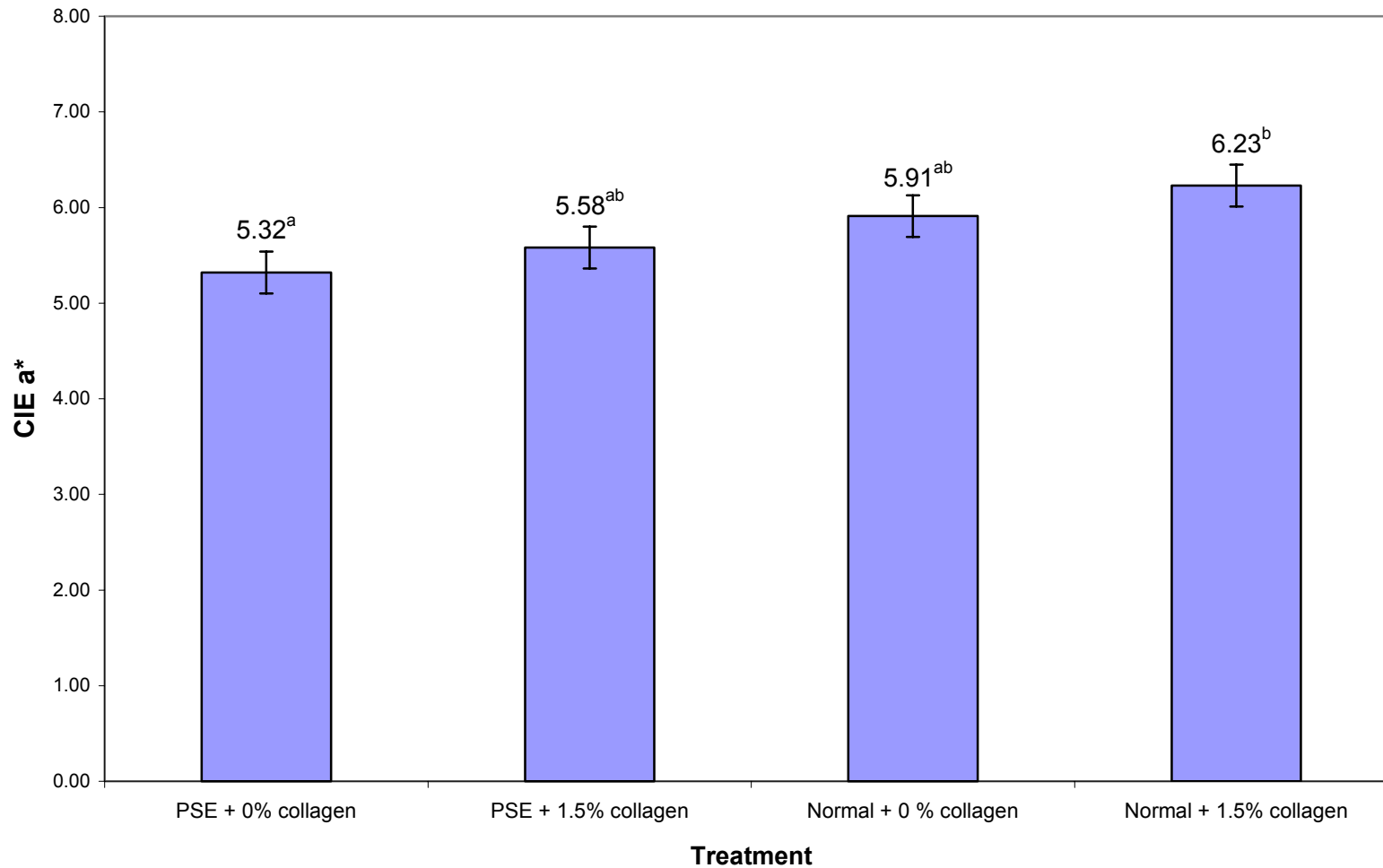
FIGURE 3.2: Effects of 0 or 1.5 % chicken collagen on the CIE a* values of chunked and formed broiler breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different ($p < 0.05$). Standard error bars are included for each treatment.
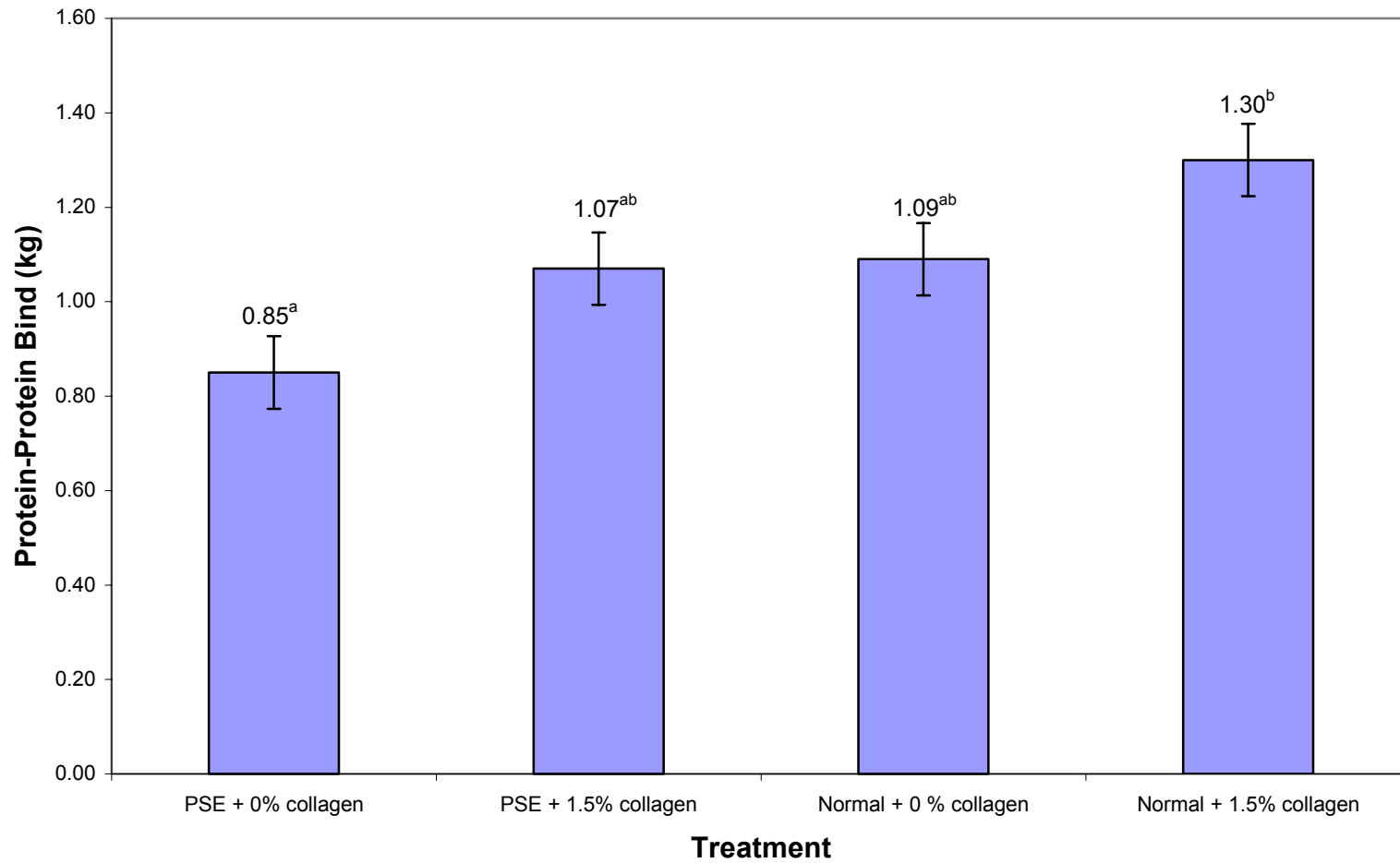
FIGURE 3.3: Effects of 0 or 1.5 % chicken collagen on the protein-protein bind of chunked and formed broiler breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different ($p < 0.05$). Standard error bars are included for each treatment.

TABLE 3.1: Effects of 1.5 % chicken collagen on the CIE L*, CIE b*, protein bind, purge loss, expressible and total moisture of chunked and formed broiler breast formulated with 100 % PSE and 100 % normal raw material

Treatment	CIE L*	CIE b*	Protein Bind: Total Energy (kg-mm)	Purge Loss (%)	Expressible Moisture (%)	Total Moisture (%)
PSE	79.6^a	10.23^a	16.1^a	3.54^a	22.7^a	73.7^a
PSE + 1.5 % collagen	79.4^{ab}	9.90^a	20.5^{ab}	3.48^a	21.2^a	74.0^a
Normal	79.0^{ab}	9.98^a	20.5^{ab}	3.20^a	21.9^a	73.9^a
Normal + 1.5 % collagen	78.2^b	10.24^a	24.3^b	2.89^a	20.2^a	73.6^a
Pooled S.E.M.	0.40	0.34	1.4	0.21	0.85	0.34

^{a,b} Means within a column with the same letter are not different (P>0.05).