CHAPTER 4

EXPERIMENT 2

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

4.1 ABSTRACT

A randomized complete block design with four treatments (100% pale, soft, and exudative (PSE), 100% PSE + 1.5% turkey collagen, 100% normal, and 100% normal + 1.5% turkey collagen) and six replications was utilized to test the effects of raw material and turkey collagen on protein functionality in the formulation of chunked and formed turkey breast. Addition of 1.5 % turkey collagen increased ($p<0.05$) the max peak force and total energy of chunked and formed treatments formulated with 100% PSE and 100% normal raw material. Utilization of 1.5 % turkey collagen also reduced ($p<0.05$) the purge loss and cooking loss of PSE and normal turkey deli rolls for higher product yields. Enhancement of turkey deli rolls with turkey collagen has the potential to add value to PSE and normal raw material through the improvement of water holding capacity and protein binding.

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

4.2 INTRODUCTION

Poultry quality has received increased concern due to the quality problems caused by production practices during the past decade. Poultry is lean, nutritious, and relatively inexpensive in comparison to red meat species, but a quality condition termed pale, soft, and exudative (PSE) has emerged (Owens et al., 2000b). Displaying negative properties such as pale color and increased moisture loss, PSE turkey also displays poor functional properties when used in further processed products. Increased success of poultry products can be credited to the ability of the industry to produce economically acceptable products. The effort to provide larger birds for slaughter at a younger age coupled with inadequate chilling practices has lead to the development of PSE quality characteristics (Alvarado and Sams, 2003). Selection for increased growth has resulted in rapid growing muscle fibers with less developed connective tissue (Swatland, 1989). Swatland (1990) demonstrated that the outgrowth of turkey breast muscle fibers over the supportive connective tissue may predispose products to fragmentation and poor cohesion. It is believed that during this selection process, a mutation developed in the genetic material initiating a reduction in poultry quality, texture, and flavor (Anthony, 1998). Wang et al., (1999) hypothesized that a certain population of commercial turkeys may have an altered sarcoplasmic reticulum Ca^{++} channel protein resulting in abnormal activity, thus leading to the development of PSE meat. Combinations of these changes are strongly influential on the biochemical alterations occurring in the muscle during rigor mortis, which is directly responsible for the production of PSE meat.

Although PSE meat is initially observed in the fresh state, its utilization can be devastating in further processed products. Products formulated with PSE meat exhibit cracking, pale color, and are dry, all of which are the consequence of protein denaturation. Reports of PSE

in turkey meat have ranged from incidences between 5-30% (Owens et al., 2000b; Barbut, 1996; 1997; McCurdy et al., 1996). The occurrence of PSE poultry is highly variable, but it has been estimated that this pervasive problem can cost each plant approximately $4.4 million per year (Sams, 2002).

To improve the value of this low quality meat, protein functionality must be increased in order to improve texture, color, and water retention. Marination of meat has been used as a means to improve moisture, flavor, and functionality (Smith and Acton, 2001). Pork collagen has been found to improve the water-holding capacity and texture of PSE pork in restructured boneless deli rolls through increasing protein functionality (Schilling et al., 2003; Prabhu et al., 2000, 2003).

The objective of this study was to add value to this low value raw material as well as develop a niche for PSE raw material currently sold only in the fresh state (McKee and Sams, 1998). Incorporating more moisture into a product provides improved yield for the processor and a tender, juicier product for the consumer (Smith and Acton, 2001).

4.3 MATERIALS AND METHODS

4.3.1 Turkey Breast Raw Materials

Turkey breasts were obtained from a commercial poultry processing plant in Virginia from market 18-week old toms at 24-48 h postmortem. PSE and normal turkey 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 >56

and normal samples with a CIE L* value of <51 were utilized (Barbut, 1997; Owens et al., 2000a).

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 PSE 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 turkey 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 (88 kPa) with a vacuum packaging machine (KOCH Supplies Inc., Model Nirovac X 180 Digi-gas, Kansas City MO), and stored in a cooler (4°C).

4.3.2 Treatment Combinations

Turkey breast treatments consisted of 100% PSE, 100% PSE + 1.5% turkey collagen (Model T5501, Proliant, Ames, IA), 100% normal, and 100% normal + 1.5% turkey collagen (Model T5501, Proliant, Ames, IA).

4.3.3 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 2.0% salt on a finished product basis (FPB) was utilized in the marinade. 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. Turkey collagen was incorporated as a dry mixture evenly distributed in the tumbler over the brine and sample treatment.

The treatments were then individually tumbled (20 rpm) under vacuum (72.7 kPa) at 4°C for 1.5 h, stopping every 15 min for a 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 in a 4˚C cooler. Following a storage time of 8-12 h, 12.7 mm slices were manually cut, vacuum packaged, and stored in a 4˚C cooler for cooked color, protein bind, and moisture loss determination.

4.3.4 Cooking and Chilling Loss

Individual turkey 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.

4.3.5 ***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)] x100.

4.3.6 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 vacuum sealed (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.

4.3.7 Total Moisture

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

4.3.8 Protein Bind

Protein bind strength was evaluated using a procedure modified from Field et al., (1984) that utilized 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).

4.3.9 Cooked Color

Two randomly selected turkey 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.

4.3.10 Statistical Analysis

A randomized complete block design with six replications was utilized to test the treatment effects of turkey 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.

4.4 RESULTS AND DISCUSSION

4.4.1 Water-holding Capacity

Collagen inclusion decreased ($p<0.05$) cooking and chilling loss in PSE and normal treatments (Fig. 4.1). Furthermore, PSE with 1.5 % collagen demonstrated a lower cooking and chilling loss than the normal treatment without collagen. Incorporation of 1.5 % turkey collagen was also effective in decreasing ($p<0.05$) purge loss in both PSE and normal treatment (Fig. 4.2). Furthermore, PSE and 1.5 % collagen was similar ($p>0.05$) in purge loss to normal treatments without 1.5 % collagen. Collagen addition demonstrates that the inclusion of a functional protein to denatured myofibrillar proteins has the ability to add value to products by improving moisture

retention characteristics. Prabhu et al. (2000) also demonstrated that the inclusion of 1 % and 2 % pork collagen with comminuted sausages increased the cook yields over the control. Schilling et al. (2003) found that collagen inclusion to PSE pork decreased cooking loss, while Sadowska et al. (1980) also reported that collagen addition could improve water-binding through collagen-myofibrillar interaction.

Measurement of total moisture and expressible moisture revealed no differences ($p>0.05$) among all treatments (Table 4.1). This demonstrates that addition of collagen was not able to improve the functionality of PSE to bind loosely bound water in PSE turkey breasts to be similar to the normal treatments (Honikel and Hamm, 1994). Lack of statistical difference might have been attributed to utilizing 2 % NaCl concentration with only 1.5 % collagen. Schilling et al. (2003) found the expressible moisture to decrease in PSE pork when 2 % salt and 3 % pork collagen was included in the formulation, demonstrating that the inclusion of collagen to PSE adequately bind loosely bound.

4.4.2 Protein Bind

Inclusion of 1.5 % turkey collagen increased the maximum peak force and total energy of the 100% PSE treatment so that it was similar ($p>0.05$) to the 100 % normal without collagen (Fig. 4.3, Table 4.1). No difference ($p>0.05$) was seen between normal treatments for maximum peak force. PSE treatments without collagen recorded the lowest ($p<0.05$) maximum peak force and total energy, demonstrating poor protein functionality. Collagen addition demonstrated the ability to work synergistically with the myofibrillar proteins to increase textural hardness so that it was similar to the normal treatments. Kenney et al. (1992) reported similar results when connective tissue improved tensile strength in restructured beef and suggested that this improvement could be attributed to collagen forming a gel that complemented muscle protein

gelation. Furthermore, the addition of pork collagen was also found to improve the protein bind of restructured PSE pork (Schilling et al., 2003).

The lack of improvement among the normal treatments for maximum peak force could be attributed to the normal possessing functional myofibrillar proteins capable of forming adequate protein bind. In comparison, PSE treatments without collagen demonstrated poor myofibrillar functionality.

4.4.3 Cooked Color

Addition of collagen did not affect ($p>0.05$) the CIE L* or CIE a* values within PSE and normal treatments (Table 4.1). This demonstrates that collagen is not able to improve the color of PSE turkey to be similar to normal turkey, but it also does not increase the paleness of the PSE. The lack of significant difference may be attributed to the PSE raw material having a severely pale color that could not be improved to be similar to the normal treatment. The PSE treatment with collagen was paler ($p<0.05$) than the normal treatment without collagen. This difference could be attributed to the collagen retaining more moisture, which could have created a dilution effect and increased the lightness. No difference ($p>0.05$) was observed among treatments for CIE b* values (Table 4.1). Zhu and Brewer (1998) noted that PSE pork had higher CIE b* values than normal, which could also be applied to PSE poultry. Subsequently, Schilling et al. (2003) found similar results when collagen was added to PSE pork and suggested the outcome could be attributed to a yellow adjunct being added to an initially pale product.

4.5 CONCLUSIONS

Turkey collagen has the potential to reduce cooking and chilling loss, purge loss, and improve protein bind of chunked and formed deli rolls formulated with PSE turkey breasts.

Results indicate that the effects of turkey collagen may be more pronounced if incorporated at a higher percentage as well in formulations with lower quantities of PSE raw material.

4.5.1 References

Alvarado, C.Z. and Sams, A.R. 2003. Injection marination strategies for remediation of pale, soft, exudative broiler breast meat. Poultry Sci. 82, 1332-1336.

AOAC. 1995. Official Methods of Analysis, 16th Ed. Association of Official Analytical Chemists, Washington, District of Columbia.

Anthony, N.B. 1998. A review of genetic practices in poultry: Efforts to improve meat quality. J. Muscle Foods. 9, 25-33.

Barbut, S., 1997. Occurrence of pale soft exudative meat in mature turkey hens. Br. Poultry Sci. 38, 74-77.

Barbut, S. 1996. Estimates and detection of the PSE problem in young turkey breast meat. Can. J. Anim. Sci. 76, 455-457.

Duncan, D.B. 1955. A significance test for difference between ranked treatments in an analysis of variance. *Virginia J. Sci.* 2, 171-189.

Field, R.A., Williams, J.C., Prasad, V.S., Cross, H.R., Secrist, J.L., and Brewer, M.S. 1984. An objective measurement for evaluation of bind in restructured lamb roasts. J. Text. Stud. 15, 173-178.

Honikel, K.O. and Hamm, R. 1994. Measurements of water-holding capacity and juiciness. In *Quality attributes and their measurement in meat, poultry and fish products*. (Pearson, A.M. and Dutson, T.R., eds.) Ch 4, pp. 125-161. Blackie Academic & Professional, Bishopbriggs, Glasgow, United Kingdom.

McCurdy, R., Barbut, S., and Quinton, M. 1996. Seasonal effects on PSE in young turkey breast meat. Food Res. Int. 29, 363-366.

McKee, S.R. and Sams, A.R. 1998. Rigor mortis development at elevated temperatures induces pale exudative turkey meat characteristics Poultry Sci. 77, 169-174.

Owens, C.M., Hirschler, E.M., McKee, S.R., Martinez-Dawson, R., and Sams, A.R. 2000a. The characterization and incidence of pale, soft, exudative turkey meat in a commercial plant. Poultry Sci. 79, 553-558.

Owens, C.M., Matthews, N.S., and Sams, A.R. 2000b. The use of halothane gas to identify turkeys prone to developing pale, exudative meat when transported before slaughter. Poultry Sci. 79, 789-795.

Prabhu, G. January, 2003. Formulation source. In *Meat & Poultry*. 49(1), 68-75.

Prabhu, G., Doerscher, D., and Schoenberg, E. 2000. Pork collagen-product characteristics and applications in meat products. In *Proc. Institute Food Technol.* June 10-14. Dallas, Texas.

SAS. 2001. Version 8.02. Statistical Analysis System Institute Inc. Cary, North Carolina.

Schilling, M.W., Mink, L.E., Gochenour, P.S., Marriott, N.G., and Alvarado, C.Z. 2003. Utilization of pork collagen for functionality improvement of boneless cured ham manufactured from pale, soft, and exudative pork. Meat Sci. 65, 547-553.

Smith, D.P. and Acton, J.C. 2001. Marination, cooking, and curing of poultry products. In *Poultry Meat Processing*. (Sams, A. ed.) Ch 15, pp. 257-281. CRC Press LLC, Boca Raton, Florida.

Swatland, H.J. 1990. A note on the growth of connective tissues binding turkey muscle fibers together. Can. Inst. Food Sci. Technol. 23, 239-241.

Swatland, H.J. 1989. Physiology of muscle growth. In *Recent Advances in Turkey Science* (Nixey, C and Grey, T.C. eds.) Ch 7, pp. 167-182, Butterworths & Co, Borough Green, United Kingdom.

Wang, L.J., Byrem, T.M., Zarosley, J., Booren, A.M., and Strasburg, G.M. 1999. Skeletal muscle calcium channel ryanodine binding activity in genetically unimproved and commercial turkey populations. Poultry Sci. 78, 792-797

Wismer-Pedersen, J.W. 1987. Chemistry of animal tissues: Water. In *The Science of Meat and Meat Products* (Price, J.F. and Schweigert, B.S. eds.) 3rd Ed, Ch. 3, pp. 61-141. Food and Nutrition Press, Inc, Trumbull, Connecticut.

Zhu, L.G. and Brewer M.S. 1998. Discoloration of fresh pork as related to muscle and display conditions. J. Food Sci. 63(5), 763-767.

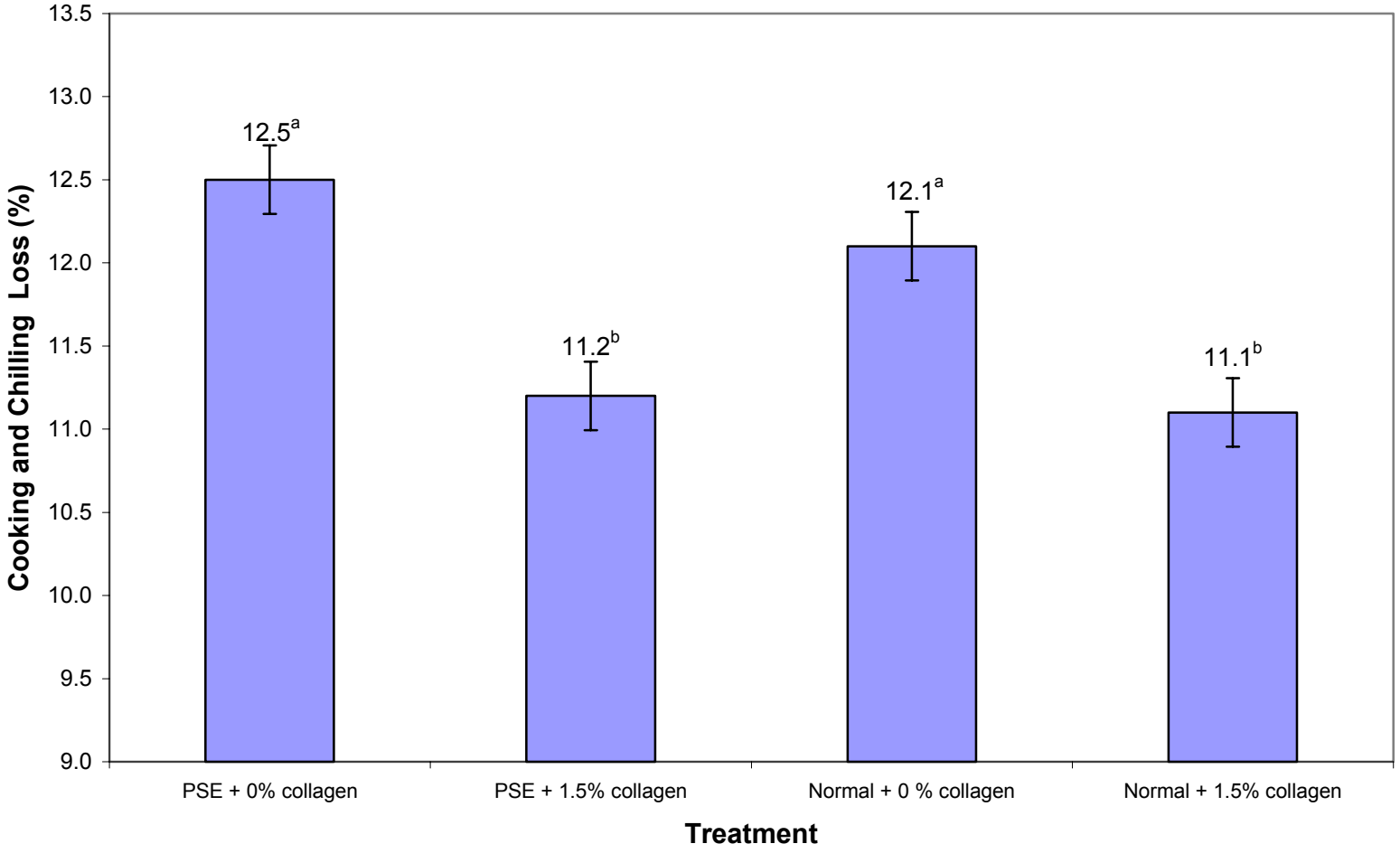

FIGURE 4.1: Effects of 0 or 1.5 % turkey collagen on the cooking and chilling loss of chunked and formed turkey breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different ($p<0.05$). Standard error bars are included for each treatment.

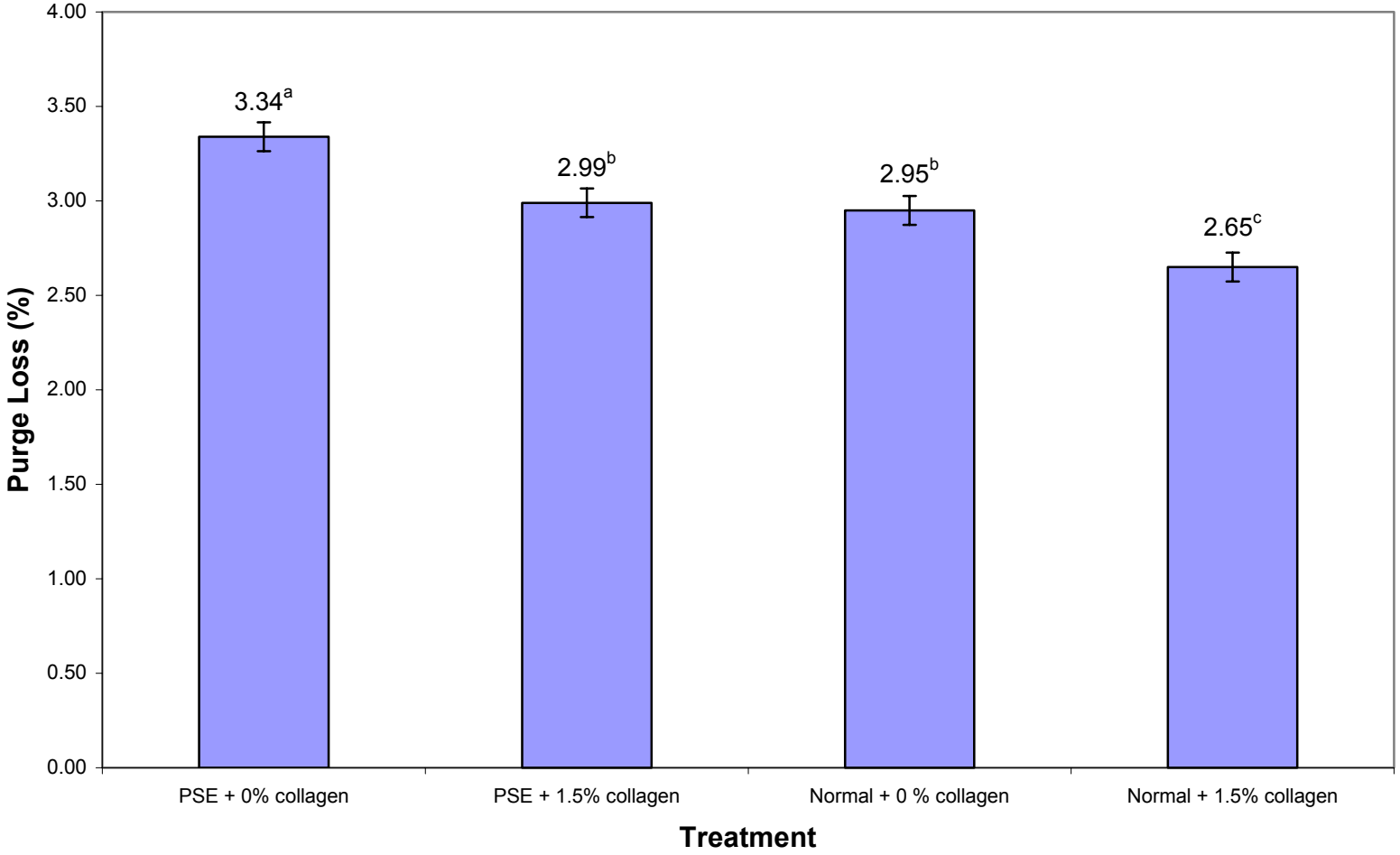

FIGURE 4.2: Effects of 0 or 1.5 % turkey collagen on the purge loss of chunked and formed turkey breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different ($p<0.05$). Standard error bars are included for each treatment.

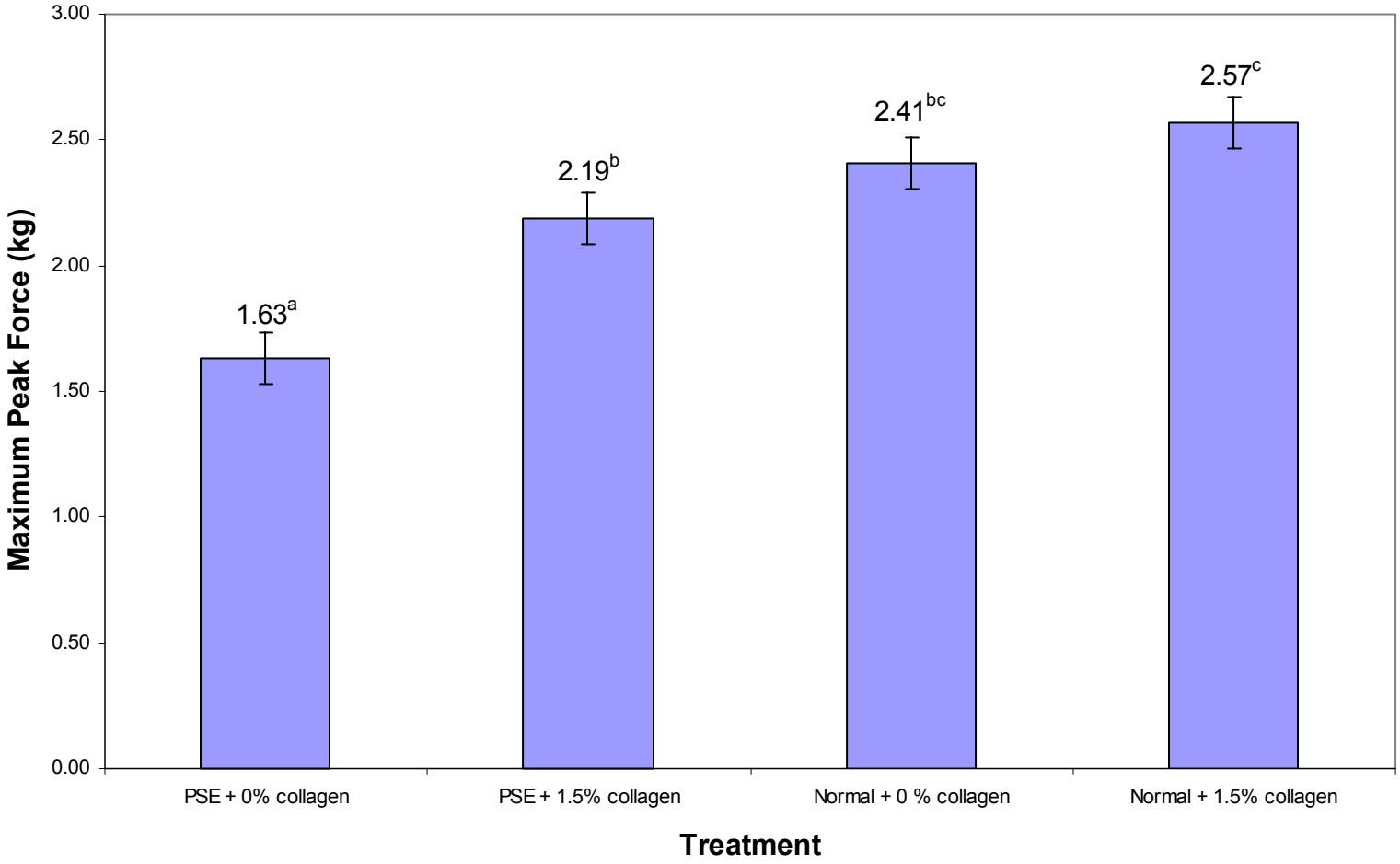

FIGURE 4.3: Effects of 0 or 1.5 % turkey collagen on the protein-protein bind of chunked and formed turkey breast formulated with 100 % PSE and 100 % normal raw material. Bar means among treatments with unlike superscripts are different ($p<0.05$). Standard error bars are included for each treatment.

TABLE 4.1: Effects of 1.5 % turkey collagen on the CIE L *, CIE a*, CIE b*, protein bind, expressible moisture, and total moisture of chunked and formed turkey breast formulated with 100 % PSE and 100 % normal raw material

Treatment	CIE L*	CIE a*	CIE b*	Protein Bind: Total Energy (kg-mm)	Expressible Moisture (%)	Total Moisture (%)
PSE	75.7[a]	6.47[a]	9.07[a]	30.0[a]	20.1[a]	74.0[a]
PSE + 1.5 % collagen	75.0[a]	6.37[a]	9.82[a]	41.6[b]	18.8[a]	72.9[a]
Normal	72.9[b]	8.02[b]	9.29[a]	44.7[b]	20.0[a]	73.6[a]
Normal + 1.5 % collagen	71.9[b]	7.75[b]	9.90[a]	52.0[c]	17.5[a]	73.2[a]
Pooled S.E.M.	0.37	0.18	0.26	2.0	0.86	0.30

[a,b] Means within a column with the same letter are not different (P>0.05).