CHAPTER 5

EXPERIMENT 3

Turkey Breast Enhancement through the Utilization of Poultry Collagen, Soy Protein, and Carrageenan in a Chunked and Formed Deli Roll

5.1 ABSTRACT

A randomized complete block design with five treatments (100% pale, soft, and exudative (PSE), 100% PSE + 1.5% collagen (TC), 100% PSE + 0.30% kappa/iota carrageenan (CG), 100% PSE + 1.5% soy protein concentrate (SPC), and 100% normal) and six replications was utilized to test the effects of raw material, turkey collagen, soy protein concentrate, and carrageenan on protein functionality in the formulation of chunked and formed turkey breast. Addition of 1.5 % soy protein and 1.5 % turkey collagen both decreased ($p<0.05$) cooking and chilling loss and increased ($p<0.005$) the protein bind of chunked and formed treatments formulated with 100% PSE raw material. Purge loss was decreased ($p<0.05$) in PSE raw material when 1.5 % turkey collagen, 1.5 % soy protein concentrate, and 0.30 % kappa/iota carrageenan were utilized. Collagen decreased ($p<0.05$) expressible moisture and displayed similar ($p>0.05$) CIE L* values to that of normal treatments, respectively. This research reveals that inclusion of turkey collagen and soy protein concentrate has the potential to improve the value of turkey deli rolls manufactured from PSE and normal raw material through the improvement of water holding capacity, protein binding and color.

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

5.2 INTRODUCTION

Pale, soft and exudative (PSE) quality characteristics develop in high temperature poultry carcasses with rapid pH decline (McKee and Sams, 1998). Selection for rapid growth in poultry has resulted in abnormally large muscle fibers with less developed connective tissue (Swatland, 1989). In this selection process it is postulated that a mutation developed in the genetic material (Anthony, 1998). Wang et al. (1999) hypothesized that a certain population of commercial turkeys may have an altered sarcoplasmic reticulum Ca^{++} channel protein leading to the development of PSE meat. Sosnicki (1993) stated that rapid growing turkeys have enlarged muscle fibers that develop faster than the connective tissues and capillaries, resulting in fiber necrosis and/or loss of connective tissue integrity. Combinations of these changes strongly influence the biochemical changes occurring in the muscle during rigor mortis, which is directly responsible for PSE.

PSE incidence in turkeys has been reported to between 5 and 40% in commercial operations (Owens et al., 2000; Woelfel et al., 1998; Barbut 1996; 1997; McCurdy et al., 1996). Although pale, soft, and exudative (PSE) meat is initially observed in the fresh state, it's effects on further processed products can be devastating. Products formulated with PSE exhibit cracking, pale color, and are dry, all of which are the consequence of protein denaturation in the raw material. PSE turkey meat is pale in color, has lower water-holding capacity, and forms softer gels (Sosnicki and Wilson, 1991; Barbut, 1993; Ferket and Foegeding, 1994; Barbut, 1997; McKee and Sams, 1997, 1998; van Laack et al., 2000). Pale color and lower water-holding capacity result in products that are unappealing, dry, and unacceptable to consumers. PSE broiler and turkey meat first occurs when a combination of rapid pH decline in postmortem

muscle with high carcass temperature causes protein denaturation which leads to pale color, poor water-holding capacity, and a soft, dry texture (Barbut, 1993; Allen et al., 1998; Sams, 1999).

Since further processed products manufactured with PSE broiler or turkey meat display poor bind, color, and water retention (McKee and Sams, 1998), enhanced usability of PSE meat can 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). PSE has been evident in pork for decades, but is relatively new to the broiler and turkey industry. It is estimated that PSE poultry can cost a processor $4.4 million dollars a year in lost meat alone, not including packaging and labor (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 broiler breast fillets has been used as a means to improve moisture, flavor, and functionality (Pearson and Gillett, 1996). Previous research has shown that the incorporation of collagen, soy protein concentrate, and carrageenan improve the protein functionality of processed meat products (Schilling et al., 2003, 2004; Prabhu et al., 2000, 2002; BeMiller and Whistler, 1996; Motzer, 1998; Pearson and Gillett, 1996). Pork collagen improves the water-holding capacity and texture of PSE pork in restructured boneless rolls through increasing protein functionality (Schilling et al., 2003). Soy protein concentrates are effective binders and extenders since they improve the cooking yield, protein content, water binding, and flavor of meat products (Pearson and Gillett, 1996). Kappa and iota carrageenan are produced from red seaweed and have been reported to increase the yield of poultry rolls by 20-80% as well as the adhesion of PSE pork in restructured hams (BeMiller and Whistler, 1996; Motzer, 1998). Addition of turkey collagen, soy protein, and carrageenan can add value to PSE turkey delicatessen rolls by improving water-holding capacity, texture, and

color characteristics through improved protein functionality. Prior utilization of these ingredients has demonstrated enhanced protein functionality with success in the areas of increased bind and moisture retention (Prabhu, 2003; Motzer et al., 1998; Pearson and Gillett, 1996).

The purpose of this research was to determine the ability of turkey collagen, soy protein, and carrageenan to increase the usability of PSE meat in chunked and formed turkey breast.

5.3. MATERIALS AND METHODS

5.3.1 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 hours postmortem. PSE and normal turkey 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., 2000).

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 turkey breasts were vacuum packaged in 15.2 x 20.3 cm, 3-mil high performance bags (KOCH Supplies, Inc., Model FreshPak Vacuum Pouches, Kansas City, MO), vacuum 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).

5.3.2 Treatment Combinations

Turkey breast treatments consisted of 100% PSE, 100% PSE with 1.5% turkey collagen (TC, Model T5501, Proliant, Ames, IA), 100% PSE with 0.30% kappa (CG, Model Gelcarin ME 6910, FMC, Princeton New Jersey) and iota carrageenan (CG, Model A-Na-Iota, FMC, Princeton NJ), 100% PSE with 1.5% soy protein concentrate (SP, Promine DS, Central Soya, Fort Wayne, IN), and 100% Normal (N).

5.3.3 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 (FPB) was utilized in the marinade solution. Soy protein concentrate and carrageenan were dissolved in the brine for the respective treatments. 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 over the brine and respective turkey chunks.

The treatments were then individually tumbled (20 rpm) under vacuum (72.7 kPa) at 4ºC for 1.5 h, stopping every 15 min 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 at 4°C 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 (88 kPa), and stored in a 4˚C cooler for cooked color, protein bind, and moisture loss determination.

5.3.4 Cooking and Chilling Loss

Individual turkey breast rolls were weighed prior to 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 value.

5.3.5 ***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.

5.3.6 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.

5.3.7 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).

5.3.8 Protein Bind

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

5.3.9 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.

5.3.10 Sensory Evaluation

Two consumer based sensory panels (n=54) were conducted to determine consumer acceptability of the restructured turkey rolls. Two replications consisting of five individual treatments were processed as 2.27 kg chunked and formed turkey rolls. Once an internal temperature of 71˚C was reached, samples were stored at 4˚C. Following 8-12 h storage, rolls were manually sliced. From each roll, 1.362 kg was used for sensory evaluation. All slices were randomly chosen. Sensory samples were sliced into 12.7 mm slices, vacuum packaged and stored in a -18°C freezer until analysis. Forty-eight hours prior to sensory analysis, the samples were thawed in a 4˚C cooler then manually cut into 19 mm cubes. A random three-digit number was used to identify the samples. All samples were individually placed in a closed plastic bag (Quart Size #487435, Ziploc Brand Bags, S.C. Johnson & Son, Inc., Racine, WI 53403-2236) and suspended in a 50˚C water bath for 5 min before sensory analysis. Each panelist evaluated five samples (100 % PSE, 100% PSE with 1.5% TC, 100% PSE with 1.5% SPC, 100% PSE with 0.30% CG, and 100 % normal). Panelists were asked to rinse their mouth with tap water between samples. Samples were evaluated using a 9-point hedonic scale. The category definitions were defined as 1-extremely dislike, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5- neither like nor dislike, 6-like slightly, 7-like moderately, 8- like very much, 9-like extremely.

5.3.11 Statistical Analysis

A randomized complete block design with six replications was utilized to test the treatment effects of TC, SPC, CG, 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.

5.4 RESULTS AND DISCUSSION

5.4.1 Water-holding Capacity

The addition of SPC and TC both decreased ($p<0.05$) the cooking and chilling loss of the treatments formulated with PSE turkey (Table 5.1). Schilling et al. (2003, 2004) also found collagen addition and SPC to decrease cooking loss in PSE pork. No differences ($p>0.05$) were seen between normal and PSE. This could be from selecting raw material that was severely pale and soft, but not severely exudative or from incorporating 2 % NaCl in the formulation. Treatments formulated with CG and PSE did not differ ($p>0.05$) from the normal treatment in cooking and chilling loss. CG may also have greater functionality when used in higher concentrations. Shand et al., (1994) and Motzer et al., (1998) also found that the addition of 0.75% kappa carrageenan to PSE restructured hams and restructured beef rolls improved the cook yield.

Treatments of normal, TC, SPC, and CG demonstrated decreased purge loss ($p<0.05$) compared to 100 % PSE treatments (Fig. 5.2). Improving the retention of moisture after being sliced and packaged allows processors to sell a juicier product to consumers. All binders demonstrated the ability to retain loosely bound water so that the treatments were similar to the normal treatments.

Incorporation of TC significantly decreased ($p<0.05$) expressible moisture (Fig. 5.1). No differences ($p>0.05$) were seen among treatments formulated with normal, PSE, SPC, and CG. Decreased expressible moisture demonstrates that water was more tightly bound by proteins when TC was included. 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 collagen addition to PSE pork decreased expressible moisture in chunked and formed deli rolls. Although no significant difference ($p>0.05$) was apparent, the addition of SPC and CG displayed potential in lowering the expressible moisture of the PSE. SPC and CG may not have been able to bind water to the effect the TC demonstrated because they do not possess muscle protein. PSE treatments with no adjunct incorporation recorded the highest ($p<0.05$) expressible moisture due to high protein denaturation. No differences ($p>0.05$) were seen among all treatments for total moisture (Table 5.1). This lack of difference among treatments could be due to the incorporation of 2% salt or not utilizing turkey that was severely exudative. Incorporating 2% salt into a formulation may have strengthened the binding properties of all treatments to the extent that total moisture was not different among treatments.

5.4.2 Protein Bind

Utilization of SPC and TC improved protein bind so that it was not different ($p>0.05$) from the normal turkey (Fig. 5.3). Incorporation of CG improved protein bind so that it was similar ($p>0.05$) to TC and SPC treatments. PSE displayed the lowest ($p<0.05$) protein-protein bind value, demonstrating poor functionality. CG, SPC and TC improved ($p<0.05$) the myofibrillar proteins so that they were able to form a gel matrix, with protein bind similar to the normal treatments.

The effect of TC is similar to the findings of Schilling et al. (2003) where pork collagen increased ($p<0.05$) the protein-protein bind of PSE pork. Furthermore, Kenney et al. (1992) demonstrated that connective tissue could improve tensile strength in restructured beef possibly due to collagen forming a gel that complemented muscle protein gelation. Motzer et al. (1998) and Shand et al. (1994) both improved the textural properties of PSE pork rolls and restructured beef with 0.5 and 1.0 % addition of kappa carrageenan. In comparison, Huang et al. (1997) reported that the shear force values of PSE to normal hams with the addition of 1 % kappa carrageenan did not increase.

5.4.3 *Cooked Color*

N had lower ($p<0.05$) CIE L* values than PSE, SPC, and CG, but was not different ($p>0.05$) from TC (Table 5.1). Treatments formulated with PSE, SPC and CG were not different ($p>0.05$) in CIE L* values, demonstrating a uniform lack of sarcoplasmic protein functionality. In comparison, Schilling et al. (2003) demonstrated that addition of 3 % collagen to 100 % PSE pork decreased ($p<0.05$) lightness in comparison to the control. Huang et al. (1994) also reported no improvement ($p>0.05$) in lightness when 1 % kappa carrageenan was added to restructured PSE hams. The researcher suggested that the addition of CG could impart a dilution effect from the increased moisture retention, causing increased lightness. This theory could also be applied to PSE and SPC since they have similar ($p>0.05$) lightness values. It is possible that the light color of the SPC and CG could have imparted lightness to an already pale product.

Addition of SPC was similar ($p>0.05$) in CIE a* value to normal (Table 5.1). No differences ($p>0.05$) were seen among TC, CG, and PSE for CIE a* values. Increased redness demonstrates improved sarcoplasmic protein functionality. In comparison, Schilling et al. (2004) reported that SPC decreased redness of PSE pork. Huang et al. (1997) also found that the

addition of 1 % carrageenan to restructured pork decreased redness of PSE hams. The pale color of TC and CG coupled with an already pale product could have also attributed to decreased redness.

Measurement of CIE b* values demonstrated that the addition of TC had more yellowness ($p<0.05$) than all treatments (Table 5.1). No differences ($p>0.05$) were detected among all other treatments. Zhu and Brewer (1998) noted that PSE pork had higher CIE b* values than normal, which may also hold true for applied to PSE poultry. Schilling et al., (2004) suggested that increased yellowness could be attributed to a yellow adjunct being added to an initially pale product. These suggestions could also hold true for CG and SPC, which are both light in color. Furthermore, these results indicate that if TC, SPC, and CG were used in a poultry product it would be advantageous to also incorporate ingredients that impart a darker color, without reduced functionality.

5.4.4 Sensory Evaluation

No difference ($p>0.05$) was found between the acceptability of treatments formulated with PSE, TC, CG, SPC, and normal. This demonstrates that incorporation of CG, SPC, and TC did not negatively affect the sensory characteristics. All samples received mean scores of six to seven indicating that all treatments were liked slightly or liked moderately. Selection criteria for the PSE and normal poultry were the same for all experiments, suggesting that the PSE turkey was not exudative enough. The addition of 2.0 % salt and 0.5 % sodium triphosphate might have also been a high enough concentration to mask the severe PSE characteristics during sensory evaluation. Restructured PSE slices demonstrated little or no visual cracking, typically seen when proteins are denatured in restructured meat products.

5.5 CONCLUSIONS

TC and SPC improved cooking and chilling loss, protein bind, and expressible moisture. TC also decreased the lightness of chunked and formed rolls formulated with PSE turkey. CG improved protein bind. Utilization of these adjuncts may be more effective when utilized together with the appropriate usage level for each adjunct requiring further investigation.

5.5.1 References

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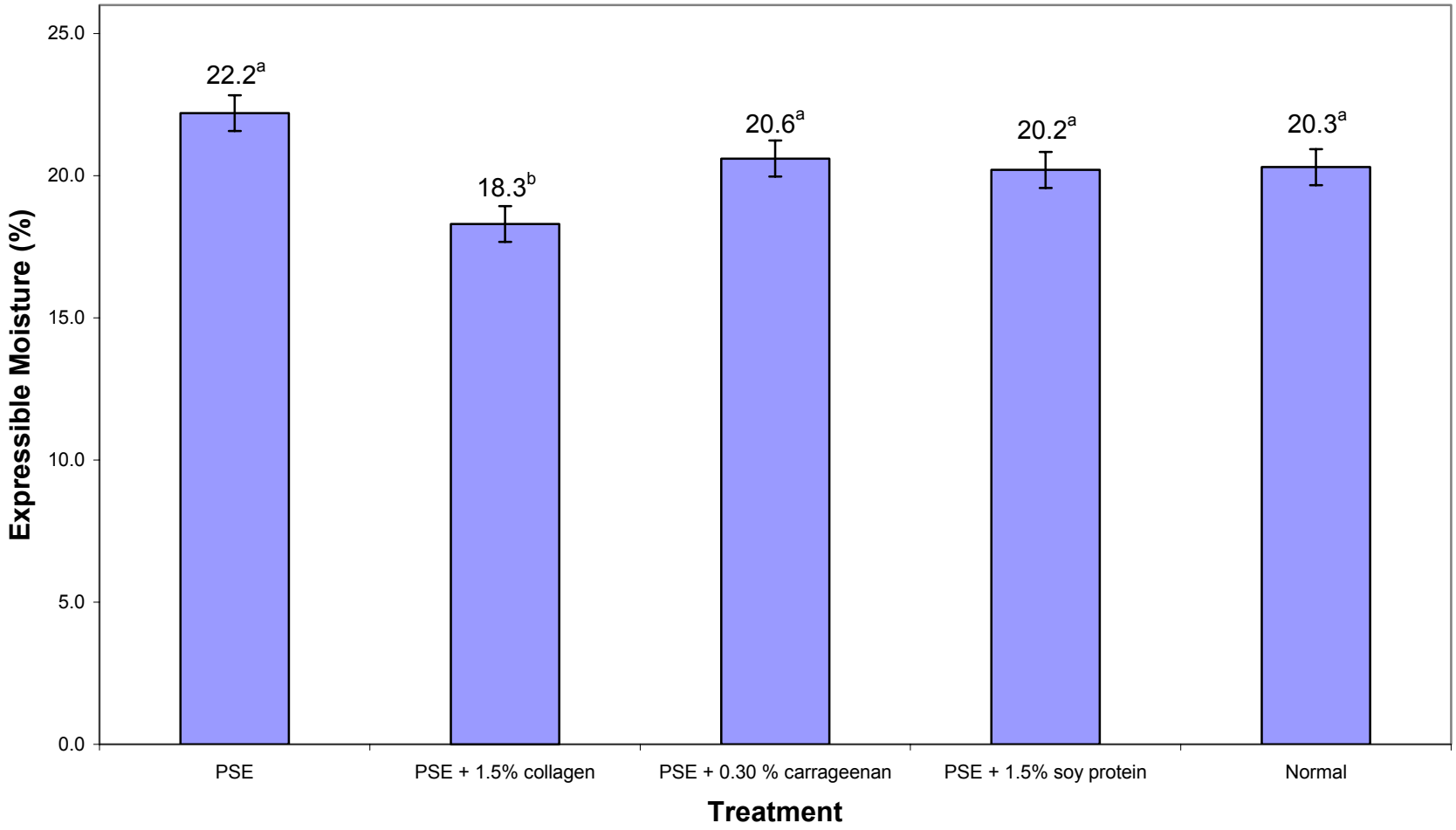

FIGURE 5.1: Effects of 1.5 % collagen, 0.30 % carrageenan, or 1.5 % soy protein on the expressible moisture of chunked and formed turkey breast formulated with 100 % PSE raw material. Bar means among treatments with unlike superscripts are different ($p<0.05$). Standard error bars are included for each treatment.

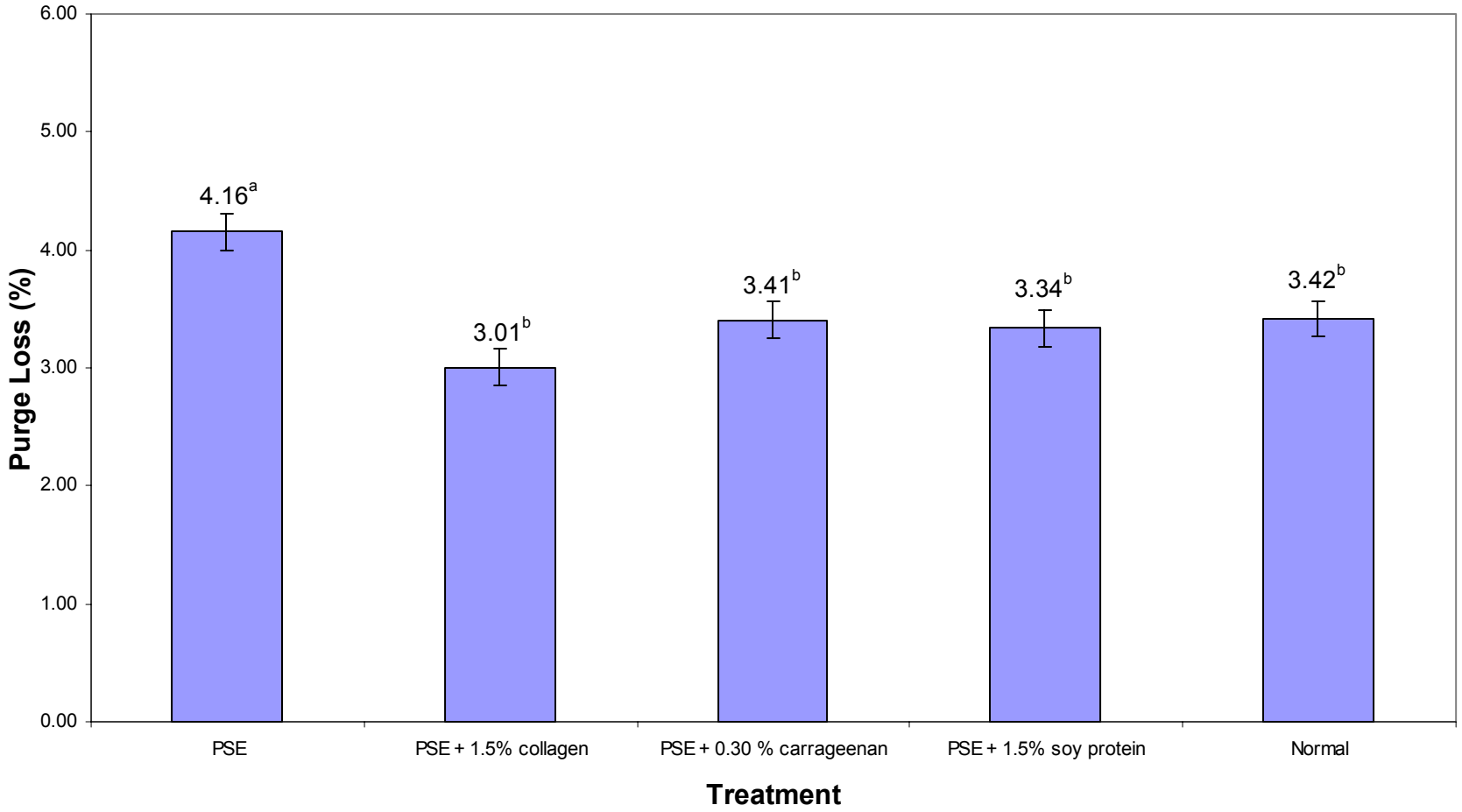

FIGURE 5.2: Effects of 1.5 % collagen, 0.30 % carrageenan, or 1.5 % soy protein on the purge loss of chunked and formed turkey breast formulated with 100 % PSE raw material. Bar means among treatments with unlike superscript letters are different ($p<0.05$). Standard error bars are included for each treatment.

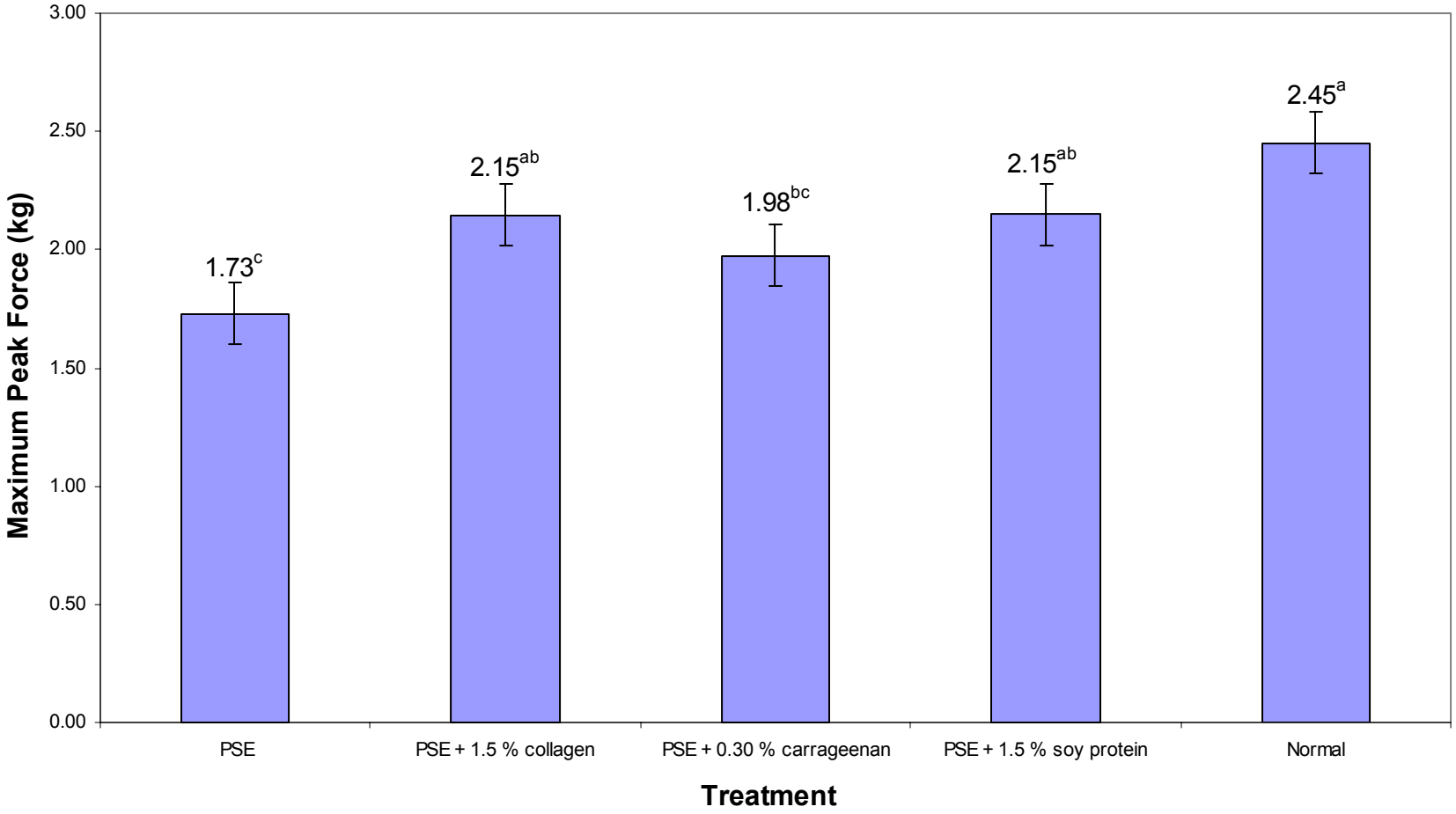

FIGURE 5.3: Effects of 1.5 % collagen, 0.30 % carrageenan, or 1.5 % soy protein on the protein-protein bind of chunked and formed turkey breast formulated with 100 % PSE raw material. Bar means among treatments with unlike superscript letters are different ($p<0.05$). Standard error bars are included for each treatment.

TABLE 5.1: Effects of 1.5 % turkey collagen, 0.30 % carrageenan and 1.5 % soy protein on the CIE values, cooking & chilling loss, and total moisture of chunked and formed turkey breast formulated with 100 % PSE

Treatment	CIE L*	CIE a*	CIE b*	Cooking & Chilling Loss (%)	Total Moisture (%)
PSE	75.0[a]	6.24[b]	9.48[ab]	10.6[a]	74.7[a]
PSE + 1.5 % collagen	73.7[ab]	6.42[b]	9.90[a]	9.5[b]	74.3[a]
PSE + 0.30 % carrageenan	74.5[a]	6.53[b]	9.35[b]	10.0[ab]	74.3[a]
PSE + 1.5 % soy protein	74.7[a]	6.96[ab]	9.44[b]	9.5[b]	74.2[a]
Normal	72.1[b]	7.92[a]	9.12[b]	10.6[a]	73.2[a]
Pooled S.E.M.	0.57	0.33	0.15	0.27	0.50

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

Table 5.2: Mean sensory score on a 9-pt hedonic scale for overall preference of PSE turkey breasts marinated with 1.5 % turkey collagen, 0.30 % carrageenan, or 1.5 % soy protein compared to normal turkey breast

Treatment	Mean Hedonic Scale Value[1]
PSE	6.84[a]
PSE + 1.5 % collagen	6.21[a]
PSE + 0.30 % carrageenan	6.37[a]
PSE + 1.5 % soy protein	6.00[a]
Normal	6.69[a]
Pooled S.E.M.	0.67

[a,b] Means within a column with the same letter are not different (P>0.05).
[1]Hedonic scale scores 1 to 9 with 1 = dislike extremely, 9 = like extremely