Quality of Restructured Hams Manufactured with PSE Pork as Affected by Water Binders

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────────────── **ABSTRACT** ──────────────

Restructured hams were made from modified food starch (MFS), kappa-carrag-eenan (k-c), isolated soy protein (ISP), and processed with different levels of PSE pork [100% Normal, 50% PSE/50% Normal, 100% PSE]. Hams were ground, tumbled for 2h with a brine, stuffed, and water cooked. Bind strength values decreased and expressible moisture increased with addition of PSE pork to the ISP and k-c treatments. Incorporation of MFS decreased bind strength and expressible moisture and increased yields in the 100P treatment. Results indicated MFS enhanced the water retention of PSE pork in a restructured product.
    Key Words: PSE, starch, carrageenan, soy protein

INTRODUCTION

PSE (PALE, SOFT AND EXUDATIVE) PORK, commonly considered as a stress related disorder, has caused economic and processing losses to the swine industry. Certain breeds of pigs have a genetic defect causing them to be more susceptible to stress. The onset of PSE results from a balance between a rapid pH decline (from 7.0 to 5.2-5.3, Claus et al., 1994) and a higher to moderate muscle temperature postmortem. Researchers reported that drip losses, muscle softness and pale musculature were linked specifically to the denaturation of myosin (Bendall and Wismer-Pederson, 1962; Offer, 1991), and sarcoplasmic proteins (Bendall and Wismer-Pederson, 1962; Van Laack et al., 1994). PSE muscle tends to exhibit decreased muscle protein extraction and solubility, crucial factors for meat binding and gelation in processed meat products (Vadehra and Baker, 1970; Schmidt and Trout, 1982).

Fabricated hams, to some extent, processed with the PSE condition have been evaluated. Camou and Sebranek (1991) investigated the gelation characteristics of PSE muscle proteins from pork. Although the PSE muscle protein gels exhibited decreased functionality at higher heating rates (93°C/h) enough protein was present to facilitate protein-protein interactions and gel formation. The possibility and feasibility of using PSE in processed meat products was proposed.

Additives or binders may be incorporated into meat batter, through injection and/or tumbling, to enhance the functionality of PSE muscle. Nonmeat additives have been widely used in processed meats (Bater et al., 1992; Lecomte et al., 1993; Berry, 1994; Prabhu and Sebranek, 1997). Carrageenans, sulfated linear polysaccharides, may be separated into three common fractions: kappa, lambda and iota. Kappa and iota carrageenans share the same affinity to the potassium cation for the purpose of gel formation. Production of a gel by kappa carrageenan results from helical coils arranged so that the 4-sulfate groups are aligned to enable potassium to fit between the coils neutralizing the charges on the system (Truis and Sebranek, 1996).

The structural configuration of amylose, a linear form of starch, facilitates hydrogen bonding with other polymers. These hydrogen bonds swell and weaken during thermal processing to enable the hydroxyl groups to entrap water (Luallen, 1985). Denaturation of isolated soy proteins via thermal processing causes soy proteins to unfold leaving hydrophobic groups exposed and open to aggregation (Hermansson, 1986). Soy protein fractions undergo dissociation-association reactions initiating gelation and resulting in an intricate gel matrix with entrapped molecules of water.

Our initial objectives were to separate visually and instrumentally the PSE and normal samples. The main objective was to evaluate the effectiveness of water binders and an alkaline phosphate to increase the protein binding and water-holding capabilities of processed hams made with different levels of PSE pork.

MATERIALS & METHODS

Raw material selection and brine preparation

Boneless top semimembranosus and adductor hams were selected for a 12 treatment experiment replicated three times. Four day postmortem hams were visually chosen on the basis of color. Paler, gray hams were classified as PSE according to accepted methods (National Pork Producers Council, 1991) and separated from the normal hams, pinkish and darker in color. Only severe examples of PSE hams were selected for this experiment. Two experienced researchers selected the meat each time from a commercial pork packing company. Each replication required 2 wk of testing, thus a total of 82 kg (PSE and normal) of hams were obtained per replication. Additional hams were selected each time to compensate for selection losses. Hams were placed on ice in two coolers for a 90 min trip back to the university. Each meat lot, PSE and normal, was trimmed of subcutaneous and visible fat, ink spots and connective tissue. After denuding, the hams were placed in 6°C coolers for processing the next day.

Random samples from the two lots of meat were tested in the university laboratory for pH and color to verify visual raw material separation into PSE and normal muscle groups. The pH of each sample was measured with a spear-tip probe (Model 81-63 Orion, Beverly, MA) using a hand held meter (Accumet® 1003, Fisher Scientific, Pittsburgh, PA). Calibration of the pH meter was performed with buffers pH 4 and 7 prior to each testing period. PSE hams were classified as pHu<5.8, while normal hams exhibited mean pHu values between 5.8-6.1 (Warner et al., 1997). CIE (1978) L*,a*,b* values were recorded with a hand held Minolta® Chroma Meter CR-200, ver. 3.0 (Minolta® Corp.,Ramsey, NJ). A white plate without the Ziploc™ bag (CR-A43) was used to calibrate the instrument each time prior to testing. Four random measurements were taken after the meat was placed in a Ziploc™ bag.

Twelve total treatments were formulated from a 4×3 factorial design with 3 levels of ham muscle (100P, 50/50, 100N) and 3 types of water binders k-c (Gelcarin®ME, FMC, Corp., Philadelphia, PA), modified food starch (MFS, Firm-tex®, National Starch and Chemical Company, Bridgewater, NJ) and isolated soy protein (ISP, Supro® EX31, Protein Technologies International, St. Louis, MO). The control for each level of ham muscle consisted of a brine without use of a binder. Brine formulas were based on a percentage of meat weight (Table 1). The order of

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Table 1—Brine formulations for water binder treatments

	% of meat weight	Control (g)	ISP[b] (g)	k-c[c] (g)	MFS[d] (g)
Ham	—	6804	6804	6804	6804
Water[a]	15	780	780	780	7800
ISP	1.5	—	102	—	—
k-c	0.75	—	—	51	
MFS	2	—	—	—	136
Salt	2	119	119	119	119
Dextrose	1	68	68	68	68
Sodiumphosphates	0.4	27	27	27	27
Sodium erythrobate	550 ppm	4	4	4	4
Sodium nitrite	156 ppm	0.9	0.9	0.9	0.9

aPart of water added as ice to reduce temperature of brine between 4-6°C.
bISP=isolated soy protein.
ck-c=kappa carrageenan.
dMFS=modified food starch.

addition for each brine was: phosphates (Brifisol® 512, BK Ladenburg, Simi Valley, CA); salt; MFS or k-c; dextrose (2060 Cerelose® Fine Dextrose, CPC International, Summit-Argo, IL); curing agents and ice. Brines made with ISP required addition of this protein prior to the phosphates and salts to fully hydrate the soy proteins without interference from the additives. Ice (~240 g) was added to reduce the brine temperature to 4-6°C.

Processing

Order of treatment processing per replication was randomized. PSE and/or normal ham muscles (~7g) were ground (Hobart Model 4046, Troy, OH) using a 12.7 mm plate to increase surface area and enhance penetration of brine. Each treatment was placed in a 320 mm diameter tumbler (Model MCII 10/20, Inject Star of the Americas, Brookfield, CT). The respective brine formulas for each treatment were made 30 min prior to tumbling and poured onto the meat in the tumbler. Each treatment tumbled continuously under a 25 mmHg vacuum for 2h at 4°C. Then, the hams were manually stuffed (F.Dick, Koch Supplies Inc., Kansas City, MO.) into 95 mm flat diameter, clear, water cook casings (Unilon 100, Devro-Teepak, Westchester, IL) and placed in a 6°C cooler overnight. Three logs were produced for each treatment combination. Two extra logs were used to monitor the cooking process of the hams, and were not included in the yield measurement.

Hams were thermally processed in a 150L steam-jacketed kettle (Model M-195, Legion Utensil, Co., Long Island City, NY). Initial water temperature was 60°C. Every 30 min the temperature was raised, until the hams reached an internal temperature of 68°C. Cooking of the hams averaged 98 min (range 96 to 100 min). Final water temperature was 77°C. A hand-held temperature probe (Model 90610-10 Cole Palmer, Vernon Hills, IL) was used to monitor the temperature of the kettle and hams. The cooked hams were chilled on ice and placed in a 6°C cooler overnight and peeled the next day. Logs were sliced into 12.7 mm thick slices using a Model 5406 Toledo Scale (Toledo, OH) slicer. The slices were randomized, placed in separate bags, held at 6°C overnight, and evaluated the following day. Samples used for chemical analysis were frozen(-10°C) and tested within 5 wk. Extra slices were placed in Cryovac bags and vacuum packaged with a Multivac machine (Cryovac, Duncan, SC).

Chill yield

Three logs were used for the chill yield measurement. Each uncooked stuffed log was weighed on a tared industrial scale prior to thermal processing. Logs were laid on ice overnight (12h) in the cooler. Chill yields were determined by removing the casings, blotting the individual logs with a paper towel, and weighing the cooked hams. The chill yield for each treatment is an average value for 3 logs -[(cooked weight/uncooked wt) - wt casings + clips]*100.

Expressible moisture

The techniques for this method were modified from Lee and Patel (1984), Aljawad and Bowers (1988) and Chang (1994). Expressible moisture, often associated with water-holding capacity, refers to the amount of loose water released from a food system under the application of force (Jauregui et al., 1981).

Cooked slices for each treatment were randomly selected from locations within the three logs. The slices were equilibrated (~10 to 15 min depending on temperature) to room temperature prior to evaluation. A 19 mm diameter core was taken from each 12.7 mm thick slice. Four cores per treatment were used for this test. The 19 mm diameter cores were individually weighed (g), then, transferred onto two 12.5 cm Whatman® #1 filter papers and two additional papers were placed on top of each core to absorb excess moisture. An Instron Universal Testing Machine connected via a digital interface card Instron series 5500 load frame (Instron Engineering Corp., Canton, MA) equipped with a flat round attachment (12.5 cm diameter) was used to compress the cores. Test conditions were: 500 kg load cell and 100 mm/min crosshead speed. At the onset of the test, the round attachment was positioned at the top of the two filter papers. During the test, the cores were compressed to 75% deformation and held for 15s once the deformation point was reached. After removal of the force, the core was transferred to a balance for a final weight measurement. Expressible moisture was expressed as a percentage:

[(initial wt - final wt)/(initial wt)]*100

Texture

Four cores (19 mm diameter) were randomly taken from each (12.7 mm thick) slices. The cores were placed in Ziploc™ bags and allowed to equilibrate to room temperature. Hardness, cohesiveness, and chewiness values were recorded using a TA-XT2 Texture Analyser (Texture Technologies Corp., Scarsdale, NY) interfaced with XT-RA software package (Stable Micro Systems User Guide, Surrey, UK). These attributes have been defined by Bourne (1982). After machine calibration, each sample was placed under a compression plate. Crosshead speed was set at 1.7 mm/s to a 75% compression of the core. A compression curve was displayed on the computer screen with texture measurements calculated from the curve peaks and areas under the curves.

Color

Two slices from each treatment were used for color measurement. Four total measurements (front and back of the slices) were recorded from each slice. CIE (1978) L*,a*,b* values were recorded with a hand held Minolta® Chroma Meter CR-200, ver. 3.0 (Minolta® Corp., Ramsey, NJ). A white plate without the Ziploc™ bag (CR-A43) was used to calibrate the instrument each time prior to testing. To prevent juices from contacting the sensor, each slice was placed in a Ziploc™ bag.

Bind strength

Bind strength assesses the ability of the meat pieces to adhere to each other. This test was modified from Field et al. (1984). Four, 12.7 mm thick slices, were selected from each treatment for evaluation. Nails were placed manually through each sample into the 1.6 mm holes drilled on top of a plexiglass stand to precisely position each slice for evaluation. Twenty-two nails were placed in 1 mm deep holes around a circle with a nail diameter of 4.5 mm and an inside diameter of 3.9 mm. The nail holes were drilled 0.5 mm apart. The plexiglass stand was placed on a flat surface at the base of the Instron. A rod with a welded steel ball (2 cm dia) at the end was attached to a chuck screwed into the Instron crosshead. A circular centering device was used to accurately align the steel ball with the center of the meat slice. At the onset of the test, the steel ball was positioned at the top of the meat slice. Crosshead speed was set at 100 mm/min with an elongation of 4 cm, and mean results were reported as

Table 2—Chemical and physical properties of restructured ham slices manufactured with water binders and different levels of PSE pork

Treatment	% Moisture[d]	% Fat[e]	% Protein[f]	Chill yield[g]
Binder				
Control	72.84[b]	2.49[a]	23.17[a]	92.15c
Modified food starch	73.67[a]	2.25[a]	20.47[c]	96.37[a,b]
Kappa carrageenan	73.81[a]	2.07[a]	21.36[b]	97.31[a]
Isolated soy protein	73.37[a]	2.38[a]	22.73[a]	93.76[b,c]
Level of meat				
100% Normal	74.19[a]	2.24[a]	21.10[c]	96.09[a]
50% Normal/50% PSE	73.44[b]	2.34[a]	22.06[b]	96.10[a]
100% PSE	72.63[c]	2.31[a]	22.62[a]	92.51

[a,b,c] Means in columns within treatments with the different letters were considered significantly different (P<0.05).
[d] LSD0.05 (Binder)= 0.47, LSD0.05 (Level of meat)= 0.40.
[e] LSD0.05 (Binder)= 0.52, LSD0.05 (Level of meat)= 0.45.
[f] LSD0.05 (Binder)= 0.58, LSD0.05 (Level of meat)= 0.50.
[g] LSD0.05 (Binder)= 2.96, LSD0.05 (Level of meat)= 2.56.

maximum peak height(N).

Chemical analysis and final pH

All treatments of cooked hams were analyzed for percent moisture, fat and protein. Prior to analyses, two slices from each treatment were finely ground using a commercial food processor. Percent moisture, fat and protein were determined according to AOAC (1995) procedures. Protein was evaluated with a nitrogen analyzer (Model FP-2000, LECO Corporation, St. Joseph, MI.). Final pH of the cooked hams was evaluated with a spear-tip probe.

Statistical analyses

This experiment was based on a 4 (binder) × 3 (level of meat) factorial, completely randomized block design (3 replications). All treatments were analyzed using an analysis of variance (ANOVA) procedure (SAS Institute, Inc., 1996) with a further application of Fischer's Least Significant Difference (LSD) test (P<0.05) to determine differences between treatment means. Correlation values (PROC CORR) were also computed, however only pertinent values were included here.

RESULTS & DISCUSSION

Raw material selection

Color and pHu values on the intact muscle (data not shown) were measured for this experiment in order to ensure raw material selection reliability. PSE and normal hams had mean pHu values ranging from 5.4-5.6 and 5.8-6.1, respectively. CIE L* values for PSE and normal pork were >59 and <50, re-spectively. Lower L* values indicated darker meat. Results from this experiment confirmed those of Bendall and Swatland (1988) that paleness values were inversely related to pHu.

Chemical analysis and chill yield

Both percent moisture and protein indicated differences (P<0.05) among binders and levels of meat treatments (Table 2). Regardless of source, all treatments containing binders had higher moisture levels than the control. ISP was the only binder with similar (P>0.05) percent protein values to the control. The 100P treatment had the lowest moisture (72.63%), and the highest percent protein (22.62%). Due to the leanness of the samples, neither the binder nor level of meat treatments showed differences (P>0.05) for percent fat. Prabhu and Sebranek (1997) manufactured ham slices that contained k-c and modified corn starch and reported similar ranges for percent moisture, fat and protein.

Addition of k-c produced the highest chill yield (97.31%; Table 2), despite similarities (P>0.05) between MFS and k-c treatments. Previous studies of the incorporation of k-c into processed meat products confirmed that k-c aids in increasing yields (Bater et al., 1992; Shand et al., 1994; Prabhu and Sebranek, 1997). Although the control lost the most water, the chill yield was similar (P>0.05) to the binder treatment with ISP. Meat type (PSE or normal) was important to the amount of water lost during cooking. The 50/50 blend treatment exhibited chill yields similar to the 100N treatments. The 100P treatment lost a higher amount of water (~

4% difference) in comparison with the other two levels of meat treatments. A lower chill yield was expected for this treatment, due to the partial protein denaturation of PSE muscle incorporated.

Several researchers have reported that meat products formulated with k-c had surfaces that appeared jelly like and wet, (Bater et al., 1992; Anonymous, 1985; Trudso, 1985) but none of the meat was classified as PSE. In our study, once the casings were removed, the 50/50 and 100P treatments formulated with k-c displayed a translucent undesirable, jelly like precipitate on the outside of each meat log. Upon addition of k-c into the meat via a brine, this binder swells resulting in an increased viscosity leading to gel formation. Swelling and gelation of k-c depends highly on the time/temperature relationship during cooking. This relationship became distorted when PSE was used as a raw material causing release of water and k-c from the meat log. The precipitate that collected in the casing likely formed a jelly during cooling (Lamkey, 1997).

Brine pH and final meat pH

In an attempt to increase water retention, in particular for the PSE, all treatments were prepared with an alkaline phosphate to shift the meat pH from the isoelectric point. Mean brine pH values prior to incorporation into the hams were not evaluated for statistical differences (Table 3). K-c had the highest brine pH values above 7.00 while ISP had the lowest brine pH values ranging from 6.64-6.70. Brines made with k-c, plus phosphate, appeared to have the greatest effects on final pH compared to the other treatments (Table 5).

Yasui et al. (1979) reported meat gelation depended on the pH values of the raw material. They reported that gelation of myosin, an essential myofibrillar protein necessary for binding, occurs at pH 6.0 during a temperature increase from 30-60°C. A pH of 6.0 was the optimum for myosin gelation. In our results, final pH values of the binder treatments were similar (P>0.05; Table 5). The 100N treatment had higher final pH than the 50/50 blend and 100P treatments. Although PSE and normal pork had final pH differences, Camou and Sebranek (1991) reported PSE extracts had poorer protein functionality, resulting in weak but stable gels. These gels showed evidence of protein-protein interactions without gel separation.

Color

CIE L* (lightness) values for MFS, k-c, and ISP were lower (P<0.05) than the control indicative of a darker surface (Table 5). As the level of meat changed from 100N to 100P, the L* values increased. L* values were inversely correlated (r = -0.81) with final pH, indicating that normal meat with a higher pH was darker (lower L* value). The level of meat and binder had minimal effects on red-

Table 3—Mean brine pH values for binder/level of meat treatments

	Binder			
	Control	MFS[b]	K-c[c]	ISP[d]
Level of meat				
100 Normal	6.87	6.92	7.02	6.70
50/50[a]	6.89	6.92	7.01	6.64
100 PSE	6.87	6.88	7.02	6.69

[a] 150/50=50% Normal/50% PSE.
[b] MFS=Modified food starch.
[c] K-carr= Kappa carrageenan.
[d] ISP=Isolated soy protein.

Table 4—Expressible moisture, final meat pH, and bind strength of restructured ham slices manufactured with water binders and PSE pork

Treatment	Final meat pH[d]	Expressible moisture[e] (%)	Bind strength[f] (N)
Binder			
Control	6.09[a]	13.48[a]	25.69[b]
Modified food starch	6.08[a]	6.52[c]	28.73[a,b]
Kappa carrageenan	6.12[a]	11.51[a,b]	31.41[a]
Isolated soy protein	6.08[a]	9.81[b,c]	29.06[a,b]
Level of meat			
100 % Normal	6.22[a]	7.97[b]	33.78[a]
50% Normal/50% PSE	6.12[b]	10.47[a,b]	29.22[b]
100% PSE	5.94[c]	12.54[a]	23.17[c]

[a,b,c] Means in columns within treatments with different letters are considered significantly different (P<0.05).
[d]$LSD_{0.05}$(Binder) = 0.05, $LSD_{0.05}$(Level of meat) = 0.04.
[e]$LSD_{0.05}$(Binder) = 3.31, $LSD_{0.05}$(Level of meat) = 2.87.
[f]$LSD_{0.05}$(Binder) = 4.35, $LSD_{0.05}$(Level of meat) = 3.77.

ness values. CIE b* values (yellowness) were different between ISP and MFS and between all levels of meat treatment. As PSE was added to the treatment, the b*(yellowness) increased (P<0.05).

Expressible moisture

Restructured ham slices produced with MFS expressed the least fluid (6.52%; Table 4). MFS and ISP proved to be the most effective water binders. ISP has the ability to tightly hold water within the protein matrix (Kinsella, 1976). MFS also retains water through the hydration of starch granules that swell with an increase in temperature. This swelling becomes irreversible at the gelationization temperature forming a tight gel with water trapped inside upon cooling. MFS produced lower expressible moisture for all levels of meat, particularly the 100P treatment.

The 100P treatment expressed the highest amount of free water in comparison with 100N treatment (P<0.05). Expressible moisture increased as PSE meat was incorporated into the treatments, but the 100N, 50/50 and 100P treatments were similar (P>0.05). Yasui et al. (1979) reported slower spin-spin relaxation times for myosin samples indicating myosin gelation may be responsible for the formation of a three dimensional matrix trapping and restricting the mobility of water. Due to the rapid pH drop while muscle temperature remains high, the proteins in the myofibrillar fraction become partially denatured and lose their functionality. Denaturation of myosin in PSE muscle ultimately affects the water holding capabilities of the meat system. As a consequence, products manufactured with PSE may be expected to lose higher amounts of water.

Bind strength

Bind strength, the force required for a steel ball to penetrate through a meat slice, measures the ability of meat pieces to adhere to each other. The level of meat treatments affected (P<0.05) bind strength values (Table 4) which decreased more than 10N due to the meat treatment (100N to 100P). The inherent poor functionality of PSE meat resulted in a less cohesive bind between meat pieces in the restructured slices. K-c was the only binder different (P<0.05) from the control, indicating that when adequately solubilized it improved adhesion. Shand et al. (1994) evaluated the effects of various levels of salt, temperature and k-c on the bind of structured beef rolls and reported that as salt or levels of k-c increased, the bind increased (P<0.001).

From visual observations, ISP formed a strong gel especially for the 100P treatments although there was no statistical difference. The ISP resulted in a thicker adhesion than normal for the meat pieces. Therefore, manual stuffing became difficult and often result-

ed in air pockets within the meat log. Decreasing the level of ISP or utilizing commercial stuffing practices should alleviate this problem.

Texture

Instrumental hardness values for each treatment showed differences (P<0.05) related to the binder and level of meat incorporated. Addition of MFS as a binder resulted in lower hardness values compared to the other three treatments (Fig. 1). Due to loss of structural integrity, PSE meat lost considerable water especially after thermal processing (chill yield 92.51%; Table 2). Most of the water was released due to the partially denatured myofibrillar proteins. The addition of normal meat into the 50/50 treatment probably aided in moisture retention with the MFS treatments, thereby reducing hardness values. These conclusions are supported by the lower % moisture values for 100P samples that increased upon addition of normal meat (Table 2).

Models for cohesiveness were significant for both replication and type of binder utilized but not for meat level. An interaction between the binder and level of meat was also indicated (p<0.05) (Fig.2). A decline in cohesiveness was shown across all levels of meat with MFS as the binder. K-c maintained consistent cohesiveness values for all meat treatments. MFS decreased cohesiveness values as more PSE was incorporated, while ISP and the control had opposing effects on cohesiveness. No correlation was found between bind strength and instrumental cohesiveness (r = -0.08).

The model for chewiness resembled that of cohesiveness with an interaction between

Table 5—Instrumental color values for restructured ham slices formulated with water binders and different levels of PSE pork

Treatment	Color		
	L*[d,e] (lightness)	a*[f] (redness)	b*[g] (yellowness)
Binder			
Control	65.52[a]	11.70[a]	5.97[a,b]
Modified food starch	63.76[b]	11.73[a]	5.55[b]
Kappa carrageenan	64.30[b]	11.45[a]	5.91[a,b]
Isolated soy protein	64.43[b]	11.33[a]	6.09[a]
Level of meat			
100% Normal	62.24[c]	11.79[a]	4.97[c]
50% Normal/50% PSE	64.70[b]	11.67[a]	6.07[b]
100% PSE	66.57[a]	11.19[b]	6.59[a]

[a,b,c] Means in columns within treatments with different letters were considered significantly different (P<0.05).
[d]CIE L* scale ranges from 0 (black) to 100 (white).
[e]$LSD_{0.05}$ (Binder) = 0.97, $LSD_{0.05}$ (Level of meat) = 0.84.
[f]$LSD_{0.05}$ (Binder) = 0.52, $LSD_{0.05}$ (Level of meat) = 0.45.
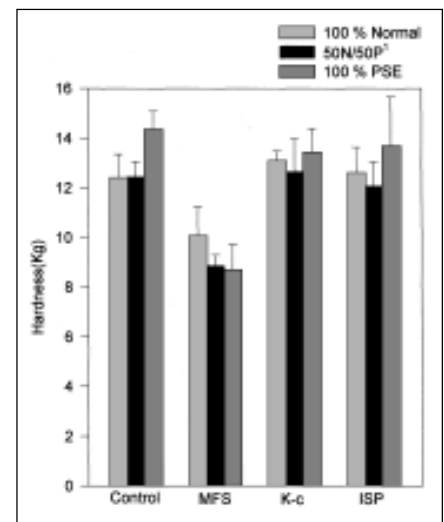[g]$LSD_{0.05}$ (Binder) = 0.45, $LSD_{0.05}$ (Level of meat) = 0.39.

Fig. 1—Effects of water binders and different levels of PSE pork on texture profile hardness (Kg) values. Control: 150N/50P = 50% normal/50% PSE treatment ; MFS = modified food starch; K-c = kappa carrageenan; ISP = isolated soy protein. Error bars represent standard deviations.
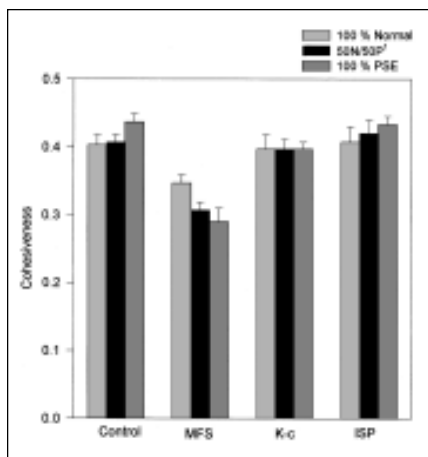
Fig. 2—Effects of water binders and different levels of PSE pork on texture profile cohesiveness values. Control: 150N/50P = 50% normal/50% PSE treatment; MFS = modified food starch; K-c = kappa carrageenan; ISP = isolated soy protein. Error bars represent standard deviations.
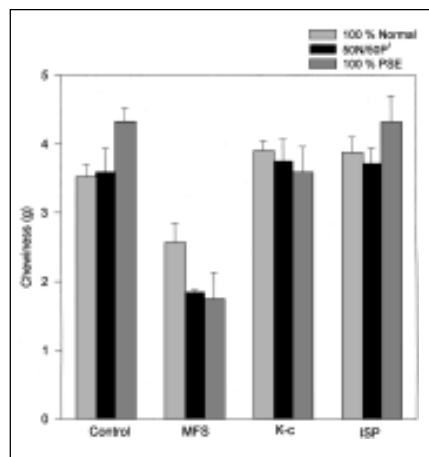

Fig. 3—Effects of water binders and different levels of PSE pork on texture profile chewiness values. Control: 150N/50P = 50% normal/50% PSE treatment; 2MFS = modified food starch; K-c = kappa carrageenan; ISP = isolated soy protein. Error bars represent standard deviations.

binders and level of meat and replication differences were also noted for chewiness (Fig.3). Hardness values did not show differences due to replication. The instrumental calculation of chewiness is a product of hardness, springiness and cohesiveness. Pearson correlation coefficients further supported the relationship between hardness, cohesiveness and chewiness. Both hardness (r = 0.92) and cohesiveness (r = 0.91) were positively correlated with chewiness.

The interaction term for the chewiness attribute was similar to that for cohesiveness. MFS resulted in the lowest chewiness values. Addition of k-c, decreased chewiness when compared with ISP and the control.

CONCLUSIONS

ADDITION OF WATER BINDERS TO THE 100N and 50/50 treatments enhanced the water-holding properties of restructured ham slices. K-c and ISP had similar moisture contents, expressible moisture and bind strength values. MFS had the greatest impact on the 100P treatment, reducing expressible moisture and decreasing hardness, cohesiveness, and chewiness values with the texture attributes exhibiting a binder/level of meat in-

teraction. Mixtures of normal meat with PSE (50/50), along with an anionic phosphate and MFS, yielded a product that resembled normal commercial restructured ham. Results suggested the possibility to increase the functionality of PSE meat to retain water especially with the use of MFS.

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