CHEMICAL PROPERTIES OF RESTRUCTURED BONELESS PORK PRODUCED FROM PSE AND RFN PORK UTILIZING MODIFIED FOOD STARCH, SODIUM CASEINATE, AND SOY PROTEIN CONCENTRATE

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Background

Pale, Soft, and Exudative (PSE) pork is a quality classification characterized as being very light colored, soft, and watery. Such meat is classified as low quality pork that is undesirable to consumers due to its poor appearance, texture, and palatability (Pearson and Gillett, 1996). This problem causes several million dollars per year in losses to the pork industry, which include excessive shrinkage, costs of sorting carcasses, customer claims, and the salvage of discounted pork in sausage manufacture. Processed meat products produced from PSE pork demonstrate poor cohesiveness, textural firmness, and cured color formation (Pearson and Gillett, 1996). The ability to produce a restructured, chunked and formed ham through the utilization of PSE pork can add utility to this lower value foodstuff since it could be used in a higher quality product than the sausage items currently being manufactured from this lower value raw material.

Objective

The objective of this study was to determine the effect of porcine raw material quality, chemical composition of raw material, and use of non-meat adjuncts on the chemical composition of restructured boneless ham rolls. This information is required to be proficient in determining what characteristics in the formulation of a boneless ham roll are important in explaining percent cooked protein, percent moisture, and cooked pH.

Methods

RFN and PSE Porcine *semimembranosus* muscles were sampled every three weeks until 3 replications of 75 treatments of boneless cured pork were produced. CIEL*, pH, moisture, and protein were measured for the samples prior to processing. Porcine *semimembranosus* and *adductor* muscles were cut into 2.5 cm by 2.5
cm cubes and 1.36 kg of these muscles were incorporated in the formulation of each treatment. Treatments consisted of 0 % PSE, 25 % PSE, 50 % PSE, 75 % PSE, and 100 % PSE raw material with the percentage difference containing RFN pork. Fifteen combinations of modified food starch (MFS, Pure-Gel B990, Grain Processing Corporation, Muscatine, IA), soy protein (SP, Promine DS, Central Soya, Fort Wayne, IN), and sodium caseinate (SC, EMSER 736, DMV USA, Onalaska, WI) were incorporated for each raw material combination. Ten percent of the meat was reduced in particle size to increase bind. The brine solution was formulated consisting of added water (25 %) Meat Weight Basis (MWB), sodium chloride (2 % MWB)), sodium tripolyphosphate (0.5 % MWB), dextrose (1 % MWB), sodium nitrite (156 ppm), and sodium erythorbate (0.042 % MWB). Ice was added to reduce the brine temperature to 4-6^o C. Each treatment was placed in a vacuum tumbler, and the brine for each treatment was poured onto the meat samples. The samples and brine were tumbled under vacuum for 1.5 hr at 4^o C. Each ham treatment was stuffed into the casings manually, and clipped to seal the casing. The samples were set in a meat lug for approximately 16 hrs (4^o C). The next day, the product was processed in a smokehouse to an internal temperature of 69^0 C.

pH, Moisture, and Protein Measurements

The pH of each *semimembranosus/adductor* muscle was measured in triplicate. pH was determined by removing three 2-g samples from three similar anatomical locations on each of the muscles and homogenized (Virtishear Model.225318, The Virtis Company, Inc., Gardener, NY) for 1 min in 20 mL of distilled deionized water. pH was measured for the individual samples with a calibrated pH meter (Model AR25, Fisher Scientific, Pittsburgh, PA) and a pH electrode (Model 13-620-298, Fisher Scientific, Pittsburgh, PA).

Percentage Moisture (39.1.02, AOAC, 1995) was measured in triplicate for each muscle using a drying oven (Model OV-490A-2, Blue, Blue Island, IL). Percentage protein (39.1.02, AOAC, 1995) was measured in duplicate using a Kiehldahl extraction apparatus (Model Rapid Still II, Labconco Corp., Kansas City, MO). All of these chemical analyses were repeated for each treatment of processed ham rolls by the same methods mentioned above.

Statistical Analysis

The experimental set-up is a constrained modified simplex mixture with 15 combinations of 3 factors (MFS, SC, SP) crossed with the 5 treatment combinations of PSE and RFN. Each of these combinations were replicated 3 times. This type of Response Surface Design allows the fitting of a second order model to model main, interaction, and quadratic effects for all effects of interest. As well it makes it possible to estimate a combination of factors to optimize a variety of responses. Percentage raw moisture, Percentage raw protein, raw pH, and raw color were also included in the regression model as main effects to provide as much explanation of the model as possible. Analysis with the statistical package SAS (Version 8.12, 2001, SAS, Cary, NC) was conducted to determine the chemical composition characteristics at various percentages of PSE pork.

Results and Discussion

Multiple linear regression demonstrated that MFS, SC, SP, raw moisture percentage and, CIEL* values explain ($p<0.05$) variation in the cooked moisture response (Equation 1) giving an R^2 of 0.3681 for the model. This R^2 is not extremely large, but it does indicate over a 60 % correlation between the significant variables in the model and the response. MFS, SC, and SP all decreased cooked moisture due to the existence of a higher percentage of solids in the boneless ham roll. Raw moisture had a positive effect on cooked moisture since it provided a greater amount of moisture going into the product. As raw material lightness increased, lower cooked moisture was exhibited. This observation occurred because PSE pork exhibits less moisture due to shrinkage of the myosin heads caused by denaturation, resulting in a lower water holding capacity (Offer and Trinick, 1983).

Cooked pH is explained ($p<0.05$) by raw material protein percent, lightness, redness, yellowness, and pH (Equation 2). The addition of non-meat adjuncts did not contribute ($p>0.05$) to the cooked pH of the boneless ham rolls. The R^2 of this model is 0.71 indicating a very good relationship between the response and the explanatory variables. The partial R^2 provided by L* and raw material pH is 0.64. The other significant variables do not add much in explanation to the model, but they do decrease the C(p) in the model signifying a reduction in bias. Raw pH was the greatest contributor to the cooked pH, but CIEL*,a *, and b* of the raw material also influenced the pH of the product. As percentage protein of the raw material increased, the cooked pH was elevated. This observation is puzzling since pale meat usually has a higher protein content than darker meat resulting from lower water holding capacity, and since darker fresh muscle has a higher pH than paler fresh meat (Offer and Trinick, 83). Cooked pH is explained by variation in raw material and not due to any non-meat adjuncts that are added to the formulation to improve protein functionality characteristics.

The first variable added to the model explaining ($p<0.05$) the majority of the percentage cooked protein is percentage protein in the raw material (Equation 3). Paleness, yellowness, and redness all explain ($p<0.05$) percent protein. The R^2 for the model is very low, equaling 0.23, but this result could be due to only taking two measurements per treatment due to high costs, leading to unexplained variation. MFS and % PSE incorporated into the product affect ($p<0.10$) the percentage cooked protein, but not at the alpha=0.05 level. However, they should be added to the regression model to lower the value of the c(p) statistic. Otherwise, the model will be underspecified, causing it to be biased. The equations incorporated were:

Equation 1:
Cooked Moisture = 71.639 – .268*MFS - .588*SC - .293*SPC +
.258*raw moisture - .104 CieL* + .244 ciea*

Equation 2:
Cooked pH = 6.16 +.0633*raw protein - .0294 cieL* - .0386*ciea* + .0329 cieb* +.267*pHraw

Equation 3:
Cooked Protein = 23.07 - .227 MFS + 0.43*rawprot - .147*CieL* - .183 ciea* + .542*cieb* + 1.6*%PSE

Conclusions

Chemical composition and quality of raw material play a larger role than the adjuncts studied in the explanation of the chemical composition of cured, boneless deli-ham rolls. Since raw material composition plays a larger role in the explanation of these characteristics, it is possible that raw material composition can also play more of a role in protein functionality characteristics of this product than the addition of non-meat adjuncts.

References

Offer, G. and Trinick J. 1983 On the Mechanism of Water Holding in Meat: The swelling and shrinking of Myofibrils. Meat Sci. 8:245-281.
Motzer, E.A., Carpenter J.A., Reynolds, A.E. and Lyon, C.E. 1998. Quality of restructured hams manufactured with PSE pork as affected by water binders. J. Food Sci. 63:1007-1011.
Pearson, A.M. and Gillett, T.A. 1996. Raw Materials. In *Processed Meats*. 3rd Ed. p. 126-143. Chapman and Hall, New York, N.Y.
SAS Institute Inc. 2001. Version 8.12. SAS Institute Inc. Cary, N.C.