

Meat and Poultry Quality and Composition – Measurement and Prediction

98: VOLATILE COMPOUNDS PROFILE OF ROASTED BEEF FROM CROSSBRED ANIMALS FINISHED ON FEEDLOT OR PASTURE

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Objectives: Aroma and flavor are important sensory attributes for roasted beef and can influence consumers' acceptance, beyond tenderness. Beef quality can be affected by several factors such as breed, age, gender, finishing system and diet. Finishing system affects growth performance, fat deposition and fatty acid composition, which leads to different lipid oxidation and aroma precursors such as oleic and linoleic acid. These precursors form different aldehydes, ketones and other compounds responsible for roasted beef aroma. As there are few studies of beef aroma compounds from animals finished on feedlot or pasture on Brazilian conditions, this study aimed verify the effects of finishing system, sire breed, cow genetic group and gender on the chemical profile of the main volatile compounds in Brazilian beef.

Materials and Methods: Beef (*longissimus thoracis* muscle) from animals of four genetic groups, bulls and heifers, the offspring of Angus or Limousin bulls and ½ Angus + ½ Nellore or ½ Simmental + ½ Nellore cows, finished on feedlot or pasture were analyzed. Beef samples of 2.5 cm were roasted in a electric oven, pre-heated at 180°C, until the sample reach an internal temperature of 75° C and ground. Solid-phase microextraction technique was used for volatile compounds extraction, using a CAR/PDMS (Carboxen/polydimethylsiloxane) fiber as stationary phase. Gas Chromatography coupled to Mass Spectrometry (GC-MS) was used to separate and identify the beef volatile compounds. Specific compounds of each volatile compound was selected, transformed to log₁₀ and analyzed by Analysis of Variance (ANOVA) by GLM procedure, where production system/diet, sire breed, cow genetic group and gender were considered as fixed effects. Means were compared by Tukey test at 5% significance level. Principal component analysis was also applied to see if there was any separation between groups within the studied effects based on the volatile compounds.

Results: Ninety-four compounds were detected and thirty-seven were selected as they were associated to beef characteristic aroma. All the studied effects affected the qualitative profile of volatile compounds on beef, being the finishing system (feedlot or pasture) and sire breed (Angus or Limousin) the major ones. For finishing system, octanal, nonanal, 1-heptanol and 3-hydroxi-2-butanone were affected. Beef from feedlot-finished animals was characterized by the presence of volatile compounds from lipid oxidation, as nonanal, octanal, octanoic and nonanoic acids, 3-hydroxi-2-butanone e 1-octen-3-ol while pasture-finished animals presented 4-heptanal, 1-pentanol, 2-methyl-pyridine, 2-ethyl-thiophene and pentanoic acid. There was no clear separation between feedlot and pasture-finished animals as expected in PCA and it can be due the fact that feedlot animals were confined for a short period of time (90 days). Sire breed presented the higher number of volatile compounds with significant difference (p<0,05) between the treatments: octanal, nonanal, 2-nonenal, 3-hydroxibutanone, 2-heptanone, 3-octanone, 2-*n*-butylfuran, 2-pentylfuran, octanoic and nonanoic acids, 1-octen-3-ol and benzaldehyde. In PCA for sire breed, a clear separation was found. Cow genetic group and gender also affected the beef volatile profile, but in minor proportion.

Conclusion: Sire breed affected more the volatile compounds profile than production system. Cow genetic group and gender had minor effect.

Keywords: Angus, aroma, GC-MS, Limousin, SPME

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99: PROPOSAL OF A VALUE-BASED GRADING SYSTEM FOR THE COMMERCIAL BEEF INDUSTRY IN THE DOMINICAN REPUBLIC

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Objectives: Management conditions of beef cattle is very different in the Central American/Caribbean region when compared with other regions in the world. Consequently, a beef grading scheme different than the one used in other regions of the world and unique to the cattle in that region is justified. Objectives of the current study were 1) to determine marketing systems used for beef cattle in the Dominican Republic, 2) to propose a value-based beef marketing system offering incentive to beef producers for providing packers with a high quality, consumer preferred product, and 3) to provide the industry with more information pertaining to possible measureable components related to beef quality.

Materials and Methods: Quality was evaluated in 96 cattle sourced from 3 commercial producers. Cattle were slaughtered under federal inspection at a commercial processing facility in the Dominican Republic. Quality characteristics measured included subcutaneous fat color (1 indicated white color; 2 indicated cream color; and 3 indicated yellow color), subcutaneous fat uniformity (1 indicated fat not evident or uniform; 2 indicated fat evident, but not uniform; and 3 indicated fat evident and uniform), muscling (1 indicated heavy muscle; 2 indicated moderate muscling; 3 indicated light muscling; and 4 indicated very light muscling), and number of permanent incisor teeth (ranging from 0 to 8) as an indicator of maturity. A proposed value-based grading grid was used with the combined score of subcutaneous fat color, subcutaneous fat uniformity, and muscling on the y-axis (3 to 10) and the number of permanent incisor teeth (0 to 8) on the x-axis. The grid was then used to assign quality scores (listed in ascending order of highest quality to lowest quality: AAA, AA, A, B, and C). Statistical analysis included determining descriptive statistics with the MEANS procedure of SAS, determining the fixed effect of producer using a multi-variance model with the MIXED procedure of SAS, and summarization with frequency distributions based on calculations with the proposed value-based grading grid.

Results: The average for each characteristic was the following: fat color was 1.81 ± 0.05 , fat uniformity was 1.01 ± 0.01 , muscling was 1.60 ± 0.05 , and the number of permanent incisor teeth was 3.27 ± 0.14 . Based on the proposed value-based grading grid, 31% of carcasses graded AAA, 16% of carcasses graded AA, 44% of carcasses graded A, 7% of carcasses graded B, and 2% of carcasses graded C. Beef carcasses from producer 1, producer 2, and producer 3 had fat color scores of 1.90 ± 0.10 , 1.73 ± 0.07 , and 1.86 ± 0.07 ; fat uniformity scores of 1.00 ± 0.02 , 1.00 ± 0.02 , and 1.02 ± 0.02 ; muscling scores of 1.85 ± 0.08 , 1.17 ± 0.06 , and 1.88 ± 0.06 ; average permanent incisor teeth of 3.50 ± 0.31 , 3.28 ± 0.23 , and 3.15 ± 0.22 ; and an average value-based grade of A₃₀, A₈₃, and A₇₀, respectively.

Conclusion: The proposed value-based grading grid was successful in differentiating beef carcasses in the Dominican Republic based on fat color, fat uniformity, muscling, and the number of permanent incisor teeth. If adopted, this grading system provides a unique system that could work for the Dominican Republic; as well as, an incentive for beef producers to produce a higher quality and more consistent product. More research is warranted in developing relationships between carcass characteristics measured in this study and consumer acceptance.

Keywords: beef, beef grading, Dominican Republic, value-based marketing

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100: IMPACT OF RELATIVE HUMIDITY AND NET TREATMENTS ON TYROPHAGUS PUTRESCENTIAE (SCHRANK) INFESTATIONS AND MOLD GROWTH ON DRY CURED HAM

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Objectives: Dry cured hams are susceptible to mite infestations which are currently controlled in the U.S. dry cured ham industry via fumigation with methyl bromide. Since methyl bromide is an ozone depleting substance, food grade ingredient infused nets have been researched as an alternative to control mite infestations on dry cured hams. Mite infestations and mold growth vary on dry cured ham in untreated and treated nets due to environmental changes in relative humidity (RH) and temperature. Therefore, the objective of this research was to evaluate the effect of RH and infused nets on mite infestations and mold growth on dry cured hams.

Materials and Methods: Patent pending food grade coating formulations consisting of 1) xanthan gum (XG) and propylene glycol (PG) and 2) carrageenan (CG), propylene glycol alginate (PGA), and PG were infused into ham nets. Dry cured ham cubes (2.5 cm³) and slices (2.5 cm x 9.0 cm x 15.5 cm) were wrapped with untreated (control) and two types of infused (treated) nets (XG + PG and CG + PGA + PG) and stored in ventilated glass jars. Three cubes and slices from each treatment were inoculated with 20 and 50 adult mites respectively, and stored in an environmental chamber for 14 days at 24 °C and 65±2, 75±2, and 85±2 % RH. Mite infestation was determined by counting the mobile mites on ham cubes, slices, and nets using a microscope. Nine trained panelists rated the moldiness of ham slice surfaces on a 0 to 100 % scale. A 3x3 factorial structure within a completely randomized design was used to determine the impact of RH and net treatment on mite infestations and mold growth. The least square means method was applied to separate treatment means.

Results: At 65% and 75% RH, samples with treated nets had fewer (P<0.05) mites than the control, but there were no differences (P>0.05) between treated and control nets at 85% RH. On average, across net treatments, there were fewer mites (P<0.05) at 75 and 85 % RH in comparison to 65 % RH. In addition, when averaged over RH, samples in XG and CG coated nets had fewer (P<0.05) mites on ham slices compared to samples in untreated nets. Though there was no difference between XG and CG (P>0.05) with respect to the number of mites on ham slices, the CG treatments were effective at controlling mites at all RHs. In contrast, the XG treatment did not control mites at 65 % RH. There was a strong correlation (r=0.98) between percentage of the ham slices covered with mold and number of mites present. Mold growth was greater (P<0.05) at 65 % RH in comparison to 75 and 85 %, and XG and CG treatments had less mold growth than the control treatments, with the CG treatment completely inhibiting the presence of visual mold.

Conclusion: Treated nets inhibited mite infestations and mold growth on ham cubes at 65% and 75% RH and on ham slices at 65% RH. Results indicate that 75 and 85 % RH would be more desirable in the ham industry if hams were aged at 24°C. Further testing will be performed to observe the impact of temperature on mite infestations and mold growth on ham cubes and slices at various RHs to optimize aging conditions that can be used to help control mite infestations.

Keywords: Dry cured hams, Food Grade Coated Nets, Mite Infestations, Relative Humidity

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101: PREDICTION EQUATIONS TO ESTIMATE CUTABILITY FROM BEEF CARCASSES PRODUCED IN COSTA RICA

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Objectives: For years the Livestock Corporation of Costa Rica (Corporacion Ganadera, CORFOGA) has been gathering extensive cut-out data with an aim to establish a primary segregation of carcasses by sex class and then by yield grades. Despite the efforts of CORFOGA and associated academic groups, no reports were found on prediction equations for estimating cutability of Costa Rican beef carcasses. Hence, data from 292 carcasses, representing cattle produced in different regions of Costa Rica under similar extensive conditions (fed pasture/forage-based diets) representing different *Bos indicus*-influenced breed types and two sex classes (156 bulls, 136 heifers or cows) were used to develop equations to estimate yield of fabrication products (bone-in and boneless cuts) and co-products (bone and fat trimmings).

Materials and Methods: The independent variables (predictors) considered for the regression analysis were: carcass weight (CWEIGHT), kidney fat (KIDNEY), carcass length (CLENGTH) leg perimeter (LEGPEN), back fat thickness (BACKFAT), external fat amount and distribution score (FINISH), loin eye area (LEA), and Achilles tendon length (LTENDON). Models were developed to predict total closely-trimmed, valuable boneless cuts (TVC) in kg [TVCKG] and percentages [TVC%]; total closely-trimmed, bone-in and boneless cuts (TC) in kg [TCKG] and percentages [TC%], bone yield percentage (PBONE), and fat trim yield percentage (PFAT). Statistical analyses included descriptive tests, correlations, residual and multiple linear regression.

Results: Unexpectedly, fatness indicators (FINISH AND BACKFAT) were not significantly associated with TVC or TC yields, probably due to the usual hot fat trimming applied during carcass dressing at the Costa Rica harvesting plant. Sex class had low (ca. 2%) to moderate (ca. 66%) influence on TVC (in kg or %), TC (in kg or %), PBONE and PFAT. Most of the variation (50% or more) in TVC, TC, BONE, and FAT could not be explained by its simple linear regression over any of the 13 carcass traits considered as potential predictors. None of the equations for predicting percentages of TVC, TC BONE and FAT showed R^2 coefficients with high numerical values. The equations which explained the highest proportion of the variability in yield of products and co-products were: TVC%: $44.375 - 1.067(\text{KIDNEY}) - 0.052(\text{CLENGTH}) + 0.069(\text{LEGPEN})$ (R^2 0.259; Mallow's-Cp: 3.19; CME 17.36). TVCKG: $18.741 + 0.414(\text{CWEIGHT}) - 3.254(\text{KIDNEY}) - 0.835(\text{LTENDON})$ (R^2 0.953; Mallow's-Cp: 4.00; CME 17.36). TC%: $70.551 + 0.663(\text{LEA})$ (R^2 0.334; Mallow's-Cp: 1.13; CME 3.03). TCKG: $8.579 + 0.628(\text{CWEIGHT}) - 4.159(\text{KIDNEY}) - 0.633(\text{LTENDON})$ (R^2 0.968; Mallow's-Cp: 4.00; CME 29.64). BONE%: $-0.021 + 0.394(\text{CWEIGHT}) + 0.394(\text{LTENDON}) - 1.639(\text{BACKFAT})$ (R^2 0.303; Mallow's-Cp: 4.00; CME 2.78). PFAT: $-0.167 + 0.058(\text{LEGPEN}) + 0.567(\text{FINISH}) - 0.148(\text{LTENDON})$ (R^2 0.190; Mallow's-Cp: 4.00; CME 1.58).

Conclusion: Given that the equations to predict percentages of TVC, TC, BONE and FAT did not show sufficient predictive capacity, future studies should consider to avoid the lack of variation in fatness indicators because of the carcass fat trimming procedure occurring in several Costa Rican packing plants. Although an eventual Costa Rican beef carcass grading program could consider the yield of cuts in absolute terms (kg) it is not recommended given the overwhelming, biased influence of carcass weight.

Keywords: Beef carcass, Beef subprimals, Cut-out yield, Prediction equation

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102: DUAL ENERGY X-RAY ABSORPTIOMETRY AS A RAPID AND NON-DESTRUCTIVE METHOD FOR DETERMINATION OF LEAN, FAT AND BONE CONTENT IN LIVESTOCK

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Objectives: In order to implement dual energy x-ray absorptiometry (DXA) as a platform technology, calibrations and development of robust equations to attain precision and accuracy are required before using for routine predictions of carcass yields in livestock. This manuscript summarized results of ongoing research where DXA has been used to estimate lean, fat, and bone carcass composition in beef, pork and lamb.

Materials and Methods: From a wide range of carcasses, a total of 334 beef (230 crossbred finished steers and 104 cows), 212 pork and 155 lamb carcasses were used to build calibration equations within each population. Left carcass sides were scanned with a Lunar iDXA unit and then dissected into lean, fat, and bone and weighed. Partial least square regression was used to carry out the prediction equations for lean, fat and bone values from primal cuts scans (independent) and actual lean, fat and bone obtained through the full dissection (dependent). The predictive ability of the models was evaluated in terms of coefficient of determination (R^2) and root mean square error of calibration (RMSE).

Results: The PLSR results between actual and DXA estimated lean and fat values showed high relationship ($R^2 > 0.97$) across all the species. Within beef, the present results suggest that DXA capacity to estimate carcass composition is independent of maturity. With regard to the bone predictions, PLSR analyses also improved the relationship for bone predictions compared to simple regression models previously developed at this institution or single pass scans for pork and lamb. Observed R^2 values for predicting bone were slightly lower than those for lean and fat estimations, particularly in those carcasses with smaller bone sizes such as pork ($R^2 = 0.889$) and lamb ($R^2 = 0.870$).

Conclusion: The results suggest that DXA technology can reliably estimate carcass composition in livestock, particularly for lean and fat estimations. Using PLSR analyses, suitable models for research have been developed from main primal scan data. However, further studies to externally validate the prediction accuracy and to obtain calibration curves for specific retail cuts or carcass cut-outs specifications are needed. Prediction accuracies for industry applications using single pass scans will also be needed.

Keywords: beef, carcass, DEXA, lamb, pork

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103: COMPARISON OF SENSORY CHARACTERISTICS, FATTY ACID PROFILES, PROXIMATE ANALYSIS, AND SHELF-LIFE STABILITY OF AKAUSHI BEEF, COMMODITY PRIME BEEF, AND TOP CHOICE BRANDED BEEF

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Objectives: The objective for this study was to compare Akaushi beef with commodity prime beef and top choice branded beef (TCB) looking at trained sensory panel attributes, tenderness, nutritional composition and shelf-life.

Materials and Methods: Striploins (n=106) were collected from two commercial beef plants. Beef type served as treatment (Akaushi top choice (Akaushi) (n=36), top choice branded (TCB) (n=36), and USDA low prime (prime) (n=34)). Striploins were selected with marbling scores of Mt to Md for the top choice products and SLAB marbling for the prime product. Striploins were fabricated into 2.54-cm steaks and assigned to various laboratory analysis after 21, 28, and 35 days of wet ageing at 4°C. Steaks from the posterior end of the striploin were displayed for four days in an atmosphere consistent with a commercial retail case lighting and temperature and were then utilized for TBARS analysis. A trained sensory panel was used to evaluate common sensory attributes. Steak types were evaluated for tenderness using Warner-Bratzler Shear Force (WBSF), proximate analysis using a Foss® Foodscan™ (Eden Prairie, MN), and fatty acid composition using gas chromatography. Differences between beef types and ageing treatments were analyzed using the mixed models procedure of SAS.

Results: Akaushi (21.8%) and prime (21.7 %) had lower protein percentage compared to TCB (22.6%) ($P<0.0001$). TCB had the highest moisture percentage, followed by Akaushi, and prime (67.9, 67.1, and 64.3%, respectively) ($P<0.0001$). TCB (47.4) had the highest percent of composite saturated fatty acids, followed by prime (46.6) and Akaushi (42.8) ($P<0.0001$). When assessing composite monounsaturated fatty acid percentages, Akaushi (53.8) was the highest, followed by prime (49.7), and TCB (48.3) ($P<0.0001$). TCB (4.4) had the highest percent of composite polyunsaturated fatty acids followed by prime (3.7) and Akaushi (3.4) ($P<0.0001$). Akaushi had the highest lipid oxidation followed by TCB, and prime ($P<0.0001$) averaging 0.5, 0.4, and 0.3 mg mal/kg of meat, respectively. Additionally, there was a difference among ageing treatments, ($P<0.0001$), with 21d (0.4) and 28d (0.4) being similar, while 35d (0.5) was more oxidized. Akaushi and prime were similar for juiciness scoring 6.0 and 6.0, respectively on a scale of 1 to 8, and both were juicier than TCB (5.6) ($P<0.05$). Akaushi (6.2) was more tender than TCB (5.8) ($P\leq 0.05$). Evaluating overall acceptability on a scale of 1 to 8, Akaushi and prime were similar (6.2 and 6.1, respectively), and both more favorable than TCB (5.8) ($P<0.05$). Average WBSF values were similar ($P=0.20$) for TCB (2.8 kg), Akaushi (2.7 kg), and prime (2.5 kg).

Conclusion: Results show that while there were differences, all three beef types would be considered very acceptable to consumers when analyzing organoleptic properties. The fatty acid profile element was diverse, as TCB had the highest percentage of polyunsaturated fatty acids, and Akaushi had the highest percentage of monounsaturated fatty acids. Akaushi beef compares well to Prime and TCB when evaluating sensory and fatty acid profile attributes; this could benefit Akaushi producers if other factors do not impede economical beef production.

Keywords: Akaushi, Beef, Fatty acids, Quality, Sensory

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104: PREDICT BEEF TENDERNESS USING IMAGE TEXTURE FEATURES

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Objectives: The aim of this study was to investigate the usefulness of image texture features extracted by computer image processing techniques to predict beef tenderness.

Materials and Methods: Fifty-eight strip loins from commercial Angus × Simmental steers were used to evaluate the effectiveness of image texture features on the predictability of beef tenderness. The average marbling score of these samples was 539.5, marbling score ranged from 360 to 820. The strip loins were vacuum packed and aged for 2 weeks under 0°C. Upon aging, 2.5-cm 13th rib steaks were cut from the center section of each loin. After blooming 10-15 mins, images were acquired using a laboratory-based color camera (NI 1776C, National Instruments, USA) with a controlled illumination system. Image background segmentation, lean/fat area separation was performed after the image acquisition (Figure 1). Image texture features, which including 88 gray level co-occurrence, 81 fast Fourier transform, and 48 Gabor wavelet filter texture features were extracted from the fresh beef strip loin steak images. After cooking, steaks were placed on a metal tray to allow to cool to room temperature. Steaks were analyzed for tenderness by the Warner-Bratzler shear force (WBSF) method. First, steaks were cooked to a final temperature of 71°C with a clamshell-style grill and cooled to room temperature, six 1.3-cm cores were removed and sheared from each steak parallel to the muscle fiber orientation. Steak samples were segregated into tougher and tender classification groups based on WBSF values whereby a WBSF of 2.0 kg or less was considered tender. A STEPWISE regression model was established to test the prediction model. Two hundred and seventeen image texture features were input as indicators for beef tenderness attributes. The subsequent textural feature selection method was analyzed by the STEPWISE method.

Table 1 STEPWISE regression model summary for beef tenderness using image texture feature as predictors

Model	R	R Square	Std. Error of the Estimate	Change Statistics		
				R Square Change	F Change	Sig. F Change
1	.47	.22	.36	.22	15.80	.00
2	.55	.30	.35	.08	6.50	.01
3	.64	.41	.32	.11	10.01	.00
4	.69	.47	.31	.06	6.02	.02
5	.73	.54	.29	.06	7.13	.01
6	.76	.58	.28	.04	5.40	.02
7	.80	.63	.26	.05	7.32	.01
8	.82	.68	.25	.04	6.43	.01
9	.85	.72	.23	.05	7.93	.01
10	.88	.77	.21	.05	11.05	.00
11	.89	.80	.20	.02	5.45	.02
12	.91	.82	.20	.02	5.37	.03

Results: The STEPWISE model regression summary result of classified tenderness according to WBSF value was shown in Table 1. STEPWISE method generated 12 useful models to predict beef tenderness through image texture features. The best model's coefficient of determination value was 0.82, which means image texture features were able to explain 82% of the variation in strip steak tenderness as determined by WBSF value.

Image:



Figure 1 Image processing procedure for steak texture feature extraction

Conclusion: This study shows the potential of image texture analysis, in combination with image processing analysis, for prediction of fresh beef tenderness.

Keywords: Beef Tenderness, Image Texture, STEPWISE

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105: QUANTIFICATION OF HEMOGLOBIN AND MYOGLOBIN IN PORK MUSCLE: EFFECT OF RINSE&CHILL TECHNOLOGY ON BLOOD REMOVAL

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Objectives: The objective of this study was to use ion exchange chromatography to measure hemoglobin (Hb) and myoglobin (Mb) content in ground and salted pork lean obtained from early post-mortem sow carcasses treated with Rinse&Chill® (RC) technology (MPSC Inc., Hudson, WI) and evaluate its efficacy to decrease blood content in the muscle, when compared to a conventional treatment.

Materials and Methods: RC technology involved vascular rinsing the carcass early postmortem using a chilled (3 °C) isotonic solution (98.5% water; balance: glucose, polyphosphates, glycerine, and maltose). Sows were electrically stunned (550 V) prior to exsanguination. Six sows were used as the conventional treatment and 6 sows received the RC process. At 30-60 minutes post-mortem, the Boston butt and picnic shoulder were deboned, ground (9.5 mm diameter plate) and mixed with 1% NaCl (w/w). Samples (~100 g) were vacuum-packaged and stored at -80°C until analysis. After thawing, samples were frozen with liquid nitrogen and ground into a fine powder for extraction and determination of total heme, Mb, and Hb. Total heme was extracted with acid acetone and determined spectrophotometrically ($\epsilon_{640\text{nm}}=4.80 \text{ mM}^{-1}\text{cm}^{-1}$). Mb and Hb were extracted with 0.01 M PBS buffer (pH 7.4) and after exchange into a 0.01 M Tris buffer (pH 8.6), the heme pigments were separated by ion exchange chromatography in a diethylaminoethyl cellulose (DE52 resin, 2 g) column. Mb was eluted with 0.05 M Tris buffer (pH 8.0) and Hb with 0.5 M NaCl solution. The amount of Mb and Hb in the corresponding eluates was determined spectrophotometrically ($\epsilon_{418\text{nm}}=125 \text{ mM}^{-1}\text{cm}^{-1}$ for Mb and $\epsilon_{414\text{nm}}=128 \text{ mM}^{-1}\text{cm}^{-1}$ for Hb). ESI-MS was used to measure the mass of polypeptides in the Mb and Hb fractions. Total heme, Mb, and Hb content in muscle extracts from the two treatments were compared using an unpaired student *t*-test.

Results: ESI-MS analysis of the Mb fraction indicated a mass of 16,954 Da which was consistent with the mass of pig Mb without its heme moiety. The Hb fraction had masses of 15,040 and 16,036 Da which was consistent with the mass of the alpha and beta chain of pig Hb, respectively, without their heme moiety. These results indicated that the chromatographic separation was satisfactory. Heme and Mb content in the muscle extracts were statistically similar, when comparing conventional to RC process. The corresponding means for heme content were 187.5 and 209.2 $\mu\text{mol/kg}$ muscle and for Mb, 151.9 and 168.1 $\mu\text{mol/kg}$ muscle. Hb content in the RC treatment was significantly lower, 39.6% on average, than that for the conventional treatment. The percentages of Mb and Hb by weight (relative to each other) in the conventional treatment were 80.9% and 19.1%, respectively. For the RC treatment, Mb was 86.4% and Hb was 13.6%.

Conclusion: The ion exchange chromatography method presented here allowed the measurement of Mb and Hb in pork lean with a satisfactory recovery compared to the total heme determination. Using Hb content in muscle extracts as a measure of blood content suggested that the RC method removed 40% more blood from the muscle compared to the conventional method, leaving still about 60% of the blood in the muscle of RC-treated pigs. The possibility to quantify Hb and Mb separately offers a method to quantitatively assess blood content in muscle.

Keywords: blood removal, hemoglobin, ion exchange chromatography, pork

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106: NUTRIENT VALUES FOR DIFFERENT TYPES OF SAUSAGE, FROM USDA RESEARCH STUDIES

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Objectives: USDA's Nutrient Data Laboratory (NDL) analyzes, evaluates and reports the nutrient content for a wide variety of different foods available in the US, based on research and consumer priorities. Representative samples and analytical data are obtained through the National Food and Nutrient Analysis Program (NFNAP). Data are publicly released in the USDA food composition database.

The objective of this study was to obtain current analytical nutrient values including proximates, vitamins and minerals for 3 different types of sausage which are highly consumed and available in the United States retail market (chorizo, beef hot dog, and Italian sausage), to update the USDA database, and to make nutrient comparisons among these products.

Materials and Methods: Nationally representative samples were collected for each type of sausage including 2 or 3 leading national brands and several store brands per type, from 12 different US locations through NFNAP. Chorizo and Italian sausage were pan-fried and beef hotdog was precooked (unheated) by the manufacturer. Samples were composited using standardized methods and analyzed for proximate nutrients (protein, moisture, fat, carbohydrates and ash), minerals and cholesterol (n= 5-17) at qualified commercial laboratories using approved AOAC's methodologies and quality control procedures such as certified reference material. Nutrient values were reported per 100 grams basis. The nutrient values were first compared using one-way ANOVA and T test for significant differences between the three types of sausage, a pairwise comparison (t-test) with the Bonferroni correction was used.

Results: Protein was lowest for beef hot dog (11.7±0.13g) compared to Italian sausage (18.2±0.54g; p<0.05) and chorizo (19.3±1.60g; p<0.05). Total fat ranged from 26.4±1.1g to 28.2±0.36g, showing no significant difference among the three products. Sodium value was significantly lower for Italian sausage (766±33.4mg) compared to chorizo (983±50.4mg; p<0.05) and for Italian sausage compared to beef hot dog (872±21.5mg; p<0.05). For calcium, iron and phosphorus, chorizo had significantly higher values than beef hot dog (p<0.05) and Italian sausage (p<0.05). Zinc was higher in Italian sausage (2.4±0.06 mg) than beef hot dog (2.1±0.08mg; p<0.05). Magnesium (range 12-30mg) and moisture (range 46-55g) differed between the three types (p<0.05).

Conclusion: Nutrient differences varied among the product types, especially for protein, moisture and magnesium, due to processing and ingredients used. Overall, comparing these sausages allows researchers and consumers to see the differences in nutrient values. Meat scientists, nutritionists, and consumers can use meat nutrient data for research, nutrition policy, and food purchase decisions. Full nutrient profiles for these products using data from these assays, as well as data for other processed meats, are available publicly at <http://www.ars.usda.gov/ba/bhnrc/ndl>.

Keywords: Nutrient, Sausage, USDA

Meat and Poultry Quality and Composition – Measurement and Prediction

107: MEAT QUALITY ASSESSMENT OF PORK FROM PIGS FED POULTRY FAT, FLAXSEED OIL, AND SUPPLEMENTED WITH VITAMIN E

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Objectives: The objective of this project was to determine the meat quality characteristics of pork from pigs fed a combination of poultry fat, flaxseed oil and supplemented with vitamin E.

Materials and Methods: Yorkshire pigs (N=96) weighing approximately 50 kg were allocated to pens based on weight and sex, over two trials. Pigs within each trial were born in the same farrowing groups and each pen was allotted two gilts or two barrows. Each pen was randomly assigned to one of 8 dietary treatments in a 4 x 2 factorial. Corn-soybean meal finisher diets (N=2; 1: 50 to 80kg, 2: 80 to 110kg) were formulated to contain 0, 2, 4 or 6% lipids and 11 (NRC, 2012) or 220 IU Vitamin E/kg. Flaxseed oil was included at 1% and the remaining lipids supplied by poultry fat. Pigs were harvested (N=8 groups) at an average pen weight of 110 ± 3 kg. Following harvest, hot carcass weight (HCW) was recorded. At 24 hours post mortem carcasses were evaluated for last rib fat thickness (LRFT), tenth rib fat thickness (TRFT), loin eye area (LEA), muscle score (MS), percent fat free lean (%FFL), color values (L*, a*, b*), ultimate pH of the ham (pHH) and loin (pHL), and National Pork Producers Council (NPPC) color (NPPCCol) and marbling score (NPPCMar). TRFT, LEA, L*, a*, b*, pHH, NPPCCol, and NPPCMar were determined on the loin eye at the 10th/11th rib interface after chilling, prior to carcass fabrication. Eight 2.54-cm thick pork chops were fabricated, individually vacuum packaged, and frozen (-20±2°C) for further analysis. Belly firmness, skin-side up (SSU) skin-side down (SSD), and thickness (BT) were determined after fabrication. Chops were thawed at 4±2°C for analysis of drip loss (DL), vacuum purge loss (VP), marinade uptake (MU), marinade cook loss (MCL), cook loss (CL), Warner-Bratzler Shear Force (WBS), proximate analysis (PA), and thiobarbituric acid reactive substances (TBARS). Sensory evaluation was performed. Statistical analysis was conducted using the GLM procedure in SAS (2002). Carcass was the experimental unit.

Results: The main effect(s) of lipid content, vitamin E concentration, and sex had no effect (P>0.05) on, HCW, LEA, %FFL, a*, b*, NPPCCol, pHH, pHL, MS, SSD, SSU, BT, DL, VP, MU, MCL, WBS, % fat, % moisture, % collagen, % protein, % salt, and TBARS. Vitamin E affected (P<0.05) LRFT, TRFT, and NPPCMar; values for LRFT (23.19 vs 21.41), TRFT (21.62 vs 19.26), and NPPCMar (1.87 vs 1.41) were greater for 220 IU vitamin E. Sex had an effect (P<0.05) on L* and CL; males had a greater L* (61.50 vs 58.86) and CL (17.14 vs 14.89). There was a Lipid x Vitamin E interaction for TRFT (P=0.0015), %FFL (P=0.0028). A Trial x Vitamin E interaction was present for TRFT (P=0.03), %FFL (P=0.0350), MS (P=0.0304), SSD (P=0.0042), SSU (P=0.0079), DL (P=0.0490), VP (P=0.0418), and Collagen % (P=0.0225). There was a Trial x Sex interaction for LRFT (P=0.0034), VP (P=0.0286), and % Moisture (P=0.0390). A lipid x sex interaction for LRFT (P=0.0031), %FFL (P=0.0164), MS (P=0.0362), and SSU (P=0.0335) and a sex by vitamin E for LRFT (P=0.0206), SSD (P=0.0003), and SSU (P=0.0018).

Conclusion: A feeding program utilizing poultry fat in combination with flaxseed oil, and Vitamin E at these levels will not negatively affect the variables for carcass composition or meat quality assessed in the project. Further analysis of fatty acid composition assessment is needed.

Keywords: Flaxseed oil, Meat Quality, Pork, Poultry fat, Vitamin E

Meat and Poultry Quality and Composition – Measurement and Prediction

108: POTENTIAL ERRORS IN DETERMINATION OF LONGISSIMUS MUSCLE AREA IN CARCASSES FROM HEIFERS FED WITH OR WITHOUT ZILPATEROL HYDROCHLORIDE

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Objectives: The objective of this study was to evaluate the sources of potential error in determination of longissimus muscle area (LMA) between the 12th and 13th ribs of carcasses from heifers fed with or without zilpaterol hydrochloride (ZH).

Materials and Methods: There are two primary potential sources of error when determining LMA. First is the location of the cut between the 12th and 13th ribs. Second is the deviation of the cut from 90 degrees perpendicular to the long axis of the longissimus muscle. An additional potential source of error could come from feeding ZH. To evaluate the relative importance of each error source, rib-loin sections were cut caudal to the 13th rib and cranial to the 11th rib from 10 carcasses: 5 from heifers supplemented with ZH (8.33 mg/kg of dry matter) and 5 from heifers not supplemented with ZH (controls). Consecutive slices (3-4 mm thick) from each rib-loin section were cut at 90 degrees to the long axis of the longissimus muscle on a band saw. To ensure structural integrity, the sections were frozen and tempered so that the muscles remained firm during cutting. Each slice was placed on a stationary platform below a camera stand and images were captured using a digital Nikon D5100 camera (Lens: Nikon AF-S DX VR Zoom-Nikkor 55-200mm f/4-5.6G IF-ED). An image of a USDA beef ribeye grid was also obtained to ensure accurate calibration of LMA. The LMA was traced using a tablet computer, allowing image magnification to ensure accurate tracings were made. The LMAs were determined for those slices that were cranial to the 13th rib and caudal to the 12th rib.

Results: Mean LMA was 99.4 sq. cm. The mean range in LMA between the 12th and 13th ribs was 8.9 sq. cm. There were no differences in the mean or range of LMA among carcasses from heifers fed ZH and controls ($P > 0.10$). Depending upon the location of the cut between the 12th and 13th ribs, the LMA could be overestimated by as much as 9.0%. This equates to approximately 0.4 yield grade units. That is, a carcass that should receive a yield grade of 3.2 could present a LMA supporting a grade of 2.8. Additional inaccuracy could occur by cutting at a sharper angle than that described by the USDA. An angle of 68 degrees (22 degrees from the desired 90 degree angle) can be created by closely following the curvature of the 13th rib, potentially overestimating LMA by 7.9%. In this study, an incorrect cutting angle could overestimate LMA as much as 7.8 sq. cm, an additional 0.4 yield grade units. Collectively, both sources of error could alter LMA as much as 16.7 sq. cm (16.9%), the equivalent of 0.8 yield grade units.

Conclusion: These data reinforce the written directions of the USDA to separate the longissimus muscle between the 12th and 13th ribs by a cut as close to 90 degrees as possible. Failure to do so could result in an overestimation of LMA by as much as 16.9%. Feeding ZH to heifers had no effect on LMA variation between the 12th and 13th ribs.

Disclosure of Interest: None Declared

Keywords: beef, longissimus, ribeye area, yield grade, zilpaterol hydrochloride

Meat and Poultry Quality and Composition – Measurement and Prediction

109: USE OF IODINE VALUE TO PREDICT COMMERCIAL SLICING YIELD AND SHELF-LIFE OF BACON

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Objectives: Typically, commercial slicing yield and shelf-life of bacon is thought to be reduced as the iodine value (IV) of fat increases, but little data exists to substantiate that hypothesis. Therefore, the objectives were to establish the relationship of IV with slicing yields and the development of lipid oxidation in bacon during 90 d of storage under food-service-style conditions.

Materials and Methods: Bellies (N=84) were selected from two populations of pigs fed diets formulated to induce a large range of IV. Bellies were then allotted to 1 of 4 treatments based on IV: Low (IV 60 to 70, \bar{x} =66.11, n=24), Med (71 to 80, \bar{x} =74.64, n=24), Hi (81 to 90, \bar{x} =85.74, n=16), VeryHi (91 to 100, \bar{x} =94.24, n=20). Fresh bellies were evaluated for initial weight, length, width, thickness, and flop, and a sample of adipose tissue was excised from the belly to evaluate IV. Bellies were manufactured into bacon and sliced at a commercial processing facility. Sliced bacon was transported to the University of Illinois. Sliced bacon slabs were weighed to calculate slicing yield. Center slices from each slab were randomly allotted to storage times of 0, 30, 60, or 90 d. Sliced bacon was stored at -40° C without an atmosphere barrier to simulate food service storage conditions. Uncooked bacon slices were evaluated for thiobarbituric acid reactive substances (TBARS) and cooked samples were rated by trained sensory panelists for oxidized odor and flavor at each time point. Shelf life data were analyzed as a one-way ANOVA repeated in time; whereas, step-wise regression was used to predict bacon slicing yield based using non-invasive measures of belly quality.

Results: Iodine value ranged from 61.7 to 98.6 in this population. Commercial bacon slicing yields decreased linearly ($P < 0.0001$; 90.4%, 83.6%, 67.6%, 60.0%) concomitant with a linear increase in IV from the Low to the VeryHi treatment ($P < 0.0001$). The step-wise regression equation to predict bacon slicing yield calculated from initial weight was: $\text{yield} = 230.24 - (0.502 \times \text{length, cm}) - (1.025 \times \text{width, cm}) - (1.125 \times \text{IV})$; and explained 62.5% ($P < 0.0001$) of the variability in commercial bacon slicing yield. In this equation, IV alone accounted for 60% of the variation in slicing yield. Lipid oxidation did not differ between Low and Med at any time ($P > 0.22$), though Hi and VeryHi had greater ($P < 0.05$) TBARS than Low and Med at 30 d and thereafter. There was no difference in TBARS between Hi and VeryHi until 90 d, where VeryHi had 0.7 mg/kg-MDA less ($P < 0.01$) than VeryHi. Panelists' evaluation of oxidized odor and flavor both followed a similar pattern to TBARS, with Hi and VeryHi having greater ($P < 0.05$) oxidized odor than Low and Med at 30 d and thereafter, but Low and Med did not differ ($P > 0.05$) at any time, nor did Hi and VeryHi differ ($P > 0.65$). Oxidized flavor of Hi and VeryHi were greater ($P < 0.03$) than Low and Med at all time points, but did not differ ($P > 0.11$) from each other. Med had greater ($P < 0.04$) oxidized flavor than Low at 60 d and 90 d.

Conclusion: Non-invasive measures of belly quality were able to predict 62.5% of variability in slicing yield and increasing IV resulted in discernable differences in lipid oxidation during 90 d of food-service-style storage. Overall, IV and fresh belly characteristics may be effective predictors of the shelf-life and slicing yield of commercially processed bacon.

Keywords: Bacon, iodine value, shelf-life, slicing yield

Meat and Poultry Quality and Composition – Measurement and Prediction

110: A CONTINUED ASSESSMENT OF LOCAL BYPRODUCTS IN BEEF FINISHING DIETS IN HONDURAS

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Objectives: The continued objective was to further investigate the potential development of nutritionally complete diets using local feedstuffs and to develop replicable management strategies.

Materials and Methods: Diets were designed to assess the gain potential of beef cattle in confined feeding systems across Honduras and the viability of local feedstuffs, rather than the intent of diet comparison. Three finishing diets were formulated using local Honduran feedstuffs such as palm kernel meal, poultry litter, and sugar cane for bulls in confinement. Diets were formulated on DM basis and targeted a positive balance of ruminal degradable protein. Management included vaccination, individual identification, implantation, and treatment of parasites upon arrival to the feeding facilities. Additionally, monensin (Monsigran; Monensin Sodium 20; Brazil) was added to all diets. Treatments HM6 through HM11 were fed in the southwest region and HM12 was fed in the central region of Honduras. Cattle were *Bos indicus* crossed with *Bos taurus* and dairy type. Bulls were fed between 68-145 d with an average of 112 d. Initial BW ranged from 231-479 kg with an average of 363 kg. Bulls were fed to a minimum end point of 400 kg (unshrunk live final BW). Descriptive analyses were performed using UNIVARIATE procedure of SAS with pen within site as the experimental unit.

Results: Considering all diets, dry matter intake ranged from 9.98 to 12.27 kg/d with an average of 10.73 kg/d. Average daily gain ranged from 0.40 to 2.41 kg with an average of 1.03 kg. Final BW averaged 482 kg with a modest variability (CV = 9.33%). Gain to feed followed similarly to ADG averaging 0.096. Hot carcass weight ranged from 197 to 347 kg with an average of 267 kg. Dressing percent reported an interval of 45.25% to 61.60% averaging 55.26% with low variability (CV = 4.77%).

Conclusion: All diets were viable options for Honduran producers to finish beef cattle depending on feedstuff or byproduct availability. Local byproducts have been effectively blended with other more traditional feedstuffs such as corn to reach sufficient protein and energy. The role byproducts can have within Honduran beef finishing systems has been demonstrated through multiple diets, in various locations across Honduras. More consistent management practices have led to increased dressing percent driven by increased carcass weight. As dressing percent and carcass weight increase, the role of byproduct use to increase beef production are verified. Subsequently, the continued development of better management practices and increased information can be utilized to conduct more intensive research on local feedstuffs and diets across Honduras.

Keywords: Beef cattle, byproducts, Honduras

Meat and Poultry Quality and Composition – Measurement and Prediction

111: EFFECT OF RESIDUAL FEED INTAKE STATUS, BREED AND POST MORTEM AGING ON CONSUMER PERCEPTION OF AND PREFERENCE FOR BEEF RIBEYE STEAKS

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Objectives: The effect of selection for efficient animals using residual feed intake (RFI) on meat sensory quality and consumer preference has had limited study. The objective of this study was to determine the effects of breed, RFI and aging on consumer sensory preference and attributes perception of beef rib-eye steaks.

Materials and Methods: Thirty-six steers were used in a 3 breed (Angus, Charolais, and Kinsella Composite) × 2 RFI level (high and low) factorial design experiment. Two aging times (4 and 18 days) were also included in the experiment. Perceived and ideal tenderness, juiciness, flavor intensity and overall acceptance of ribeye steaks were evaluated by 24 consumers prescreened to ensure that they regularly consumed high-quality steaks. Analysis of variance (ANOVA), Generalized Procrustes Analysis (GPA) and preference mapping were used to analyze consumer sensory data.

Results: Results from the ANOVA showed that consumers found no significant effect of any main factor on beef flavor intensity ($P > 0.05$). Breed significantly affected juiciness ($P = 0.0070$) and overall acceptance of steaks ($P = 0.0149$), with steaks from Angus and Charolais receiving similar juiciness and acceptance ratings. Steaks aged 18 days were slightly juicier ($P = 0.0832$) and more acceptable ($P = 0.0075$) than steaks aged 4 days. No RFI effect was observed for any sensory attribute and acceptance of steaks ($P > 0.05$). The comparison between consumers' ideal ribeye steaks and assessed samples found that sensory attributes of steaks from some treatments were different from consumers' ideal products ($P < 0.05$). About 80% of the total variation was explained by the first two dimensions of the GPA consensus configuration. GPA differentiated meat clearly by aging, with samples aged for 18 days and ideal ribeye steaks characterized as juicier, more tender and as having more intense beef flavor than samples aged for 4 days. Following GPA analysis, preference mapping was performed to correlate sensory attribute perception and consumer preference. Combined with the contour plot, results of preference mapping showed that steaks from carcasses of Angus and Kinsella Composite steers with high RFI received more appreciation from consumers than steaks from carcasses of steers with low RFI. This result suggested a negative influence of selection for efficient animals using RFI on consumer preference of ribeye steaks in some breeds.

Conclusion: Therefore, RFI can be a beneficial tool in selecting efficient animals because of its limited influence on meat sensory quality, but its possible adverse influence on consumer preference should be monitored during the selection process.

Keywords: consumer sensory analysis, feed efficiency, Generalized Procrustes Analysis, meat quality, preference mapping

Meat and Poultry Quality and Composition – Measurement and Prediction

112: COMPARISON OF PROTEOMIC CHANGES AND MEAT QUALITY BETWEEN FRESH AND FREEZE-THAWED PORK LOINS

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Objectives: Proteomic studies help us to understand various biochemical changes in meat and meat products. In the present study, a comparison of proteomic changes between fresh and freeze-thawed pork loins were carried out to identify protein markers that relate to pork quality.

Materials and Methods: *Longissimus thoracis* m. (n = 10, the 6th-12th thoracic vertebrae) were taken from pigs (Yorkshire×Landrace×Duroc, 82.2±4.3 kg carcass weight) in a commercial slaughterhouse at 24 h postmortem. The loins were cut into three pieces of 3.0 cm thickness each and randomly allocated to three treatments: FR0 (no storage); FR5 (5 days of cold storage at 0 °C); and FT5 (frozen at -20 °C for 4 days and thawed at 0 °C for 1 day). All the chops were vacuum packed in plastic bags. Meat quality characteristics such as pH, meat color (CIE L*, a*, b*, chroma and hue), drip loss and Warner-Bratzler shear force (WBSF) were analyzed. The proteins extracted from the pork loin chops were digested with trypsin, and the digested peptides were separated using LC-ESI/MS (Thermo Fisher Scientific, MA). To quantify the MS/MS spectra, MaxQuant software (ver. 1.5, Max Planck Institute of Biochemistry, Germany) was run with normalization of MS spectra followed by the label-free quantification (LFQ). Peptides and proteins were derived from the SwissProt database (*Sus scrofa*; 66493 sequences). The LFQ intensities were compared between the treatments, and significant differences were accepted at $-10 \times \log(P\text{-value}) > 13.0$. The meat quality data were analyzed with an ANOVA in SAS software (ver. 9.4), and differences among the treatments were considered to be significant at $P < 0.05$.

Results: The values of CIE L* decreased from 54.30 (FR0) to 49.98 (FT5; $P < 0.01$) by freeze-thawing, whereas pork loins stored at 0 °C were not different from those in the FR0 treatment ($P > 0.05$). In contrast, the value of CIE a* did not change by freeze-thawing ($P > 0.05$), but the FR5 samples showed a higher CIE a* (7.08) value than the other treatments ($P < 0.05$). CIE b*, chroma and hue values were increased by both cold storage and freeze-thawing ($P < 0.05$). Both WBSF (3.65 kg/cm²) and drip loss (5.61 %) were increased by freeze-thawing ($P < 0.05$), but FR0 was not significantly ($P > 0.05$) different from FR5 in terms of WBSF (2.77 kg/cm²) or drip loss (2.77%). These results indicate that 5 days of cold storage affected the pork loin color intensity very slightly, but freeze-thawing reduced the lightness of the pork loin despite of 5 days of storage. Furthermore, freeze-thawing lowered the water-holding capacity and the tenderness. A total of 29 proteins were seen to be significantly different among the treatments ($P < 0.05$). Levels of metabolic enzymes such as glyceraldehyde-3-phosphate dehydrogenase, pyruvate kinase, fructose-bisphosphate aldolase A and adenylate kinase isoenzyme 1 decreased during storage regardless of the treatments ($P < 0.05$). Structural proteins such as actin, troponin T and desmin were also decreased in both FR5 and FT5, but the other structural proteins, including myosin-4 and troponin I, were decreased in FT5 only.

Conclusion: The deterioration of pork loin quality was observed at 5 days of cold storage and freeze-thawing. The levels of sarcoplasmic proteins including metabolic enzymes were decreased by cold storage or freeze-thawing; however, myofibrillar proteins such as myosin-4 and troponin I could be decreased by freeze-thawing.

Keywords: freeze-thawing, meat quality, pork, protein