USDA Quality Grade and Degree of Doneness Effects on Nutrient Content of Beef Top Loin Steaks

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Abstract— **To determine how the nutrient content of steaks from different USDA quality grades were affected when cooked to different degrees of doneness, ten steaks were obtained from each of five Prime, five Choice, and five Select strip loins and assigned to one of five degree of doneness treatments (two sets of treatments per strip loin): raw (uncooked), medium rare (63°C), medium (71°C), well done (77°C), and very well done (82°C). Steaks were dissected into separable tissue components: lean, fat, and refuse. Lean tissue was used to obtain proximate analyses of protein, moisture, fat, and ash. With increasing degree of doneness, cooking yield and percent moisture decreased, whereas percent fat and protein increased (all $P < 0.05$). Grade did not ($P > 0.05$) influence percentage separable lean. Select steaks had ($P < 0.05$) less fat and more separable refuse than Choice and Prime steaks. As degree of doneness increased, percent separable lean decreased slightly, but only very well done steaks had ($P < 0.05$) less separable lean. With increasing grade, caloric value increased: there was a 46.1% increase in caloric values between Select and Prime steaks. There was a 9.0% increase in caloric values between medium rare and very well done steaks: for every increase in a degree of doneness, there was ~18 kJ increase in a 100 g edible portion. Degree of doneness and USDA quality grade impacted cooking yields, proximate composition, and caloric values of top loin steaks.**

Keywords— **nutrient content, degree of doneness, USDA quality grade**

I. INTRODUCTION

The USDA National Nutrient Database for Standard Reference (Nutrient Database), Release 23 *[15]* provides for national nutrition policies, diet therapy, nutrition education programs, as well as a source of information for menu calculations. In addition, USDA created the Nutrient Data Set for Retail Beef Cuts *[11]*. These resources are used to provide nutrition information for on-package labeling of nutrient claims, which becomes increasingly important with requirements such as the USDA's rule requiring nutrient labeling of single-ingredient products of meat and poultry products *[12]*.

There is a limited understanding of the role of degree of doneness on fat retention and protein concentration of beef, especially when evaluating steaks from varying USDA quality grades. Akinwunmi et al. *[1]* discussed the nutritional aspects of steaks cooked to raw, medium, and well done degrees of doneness, but neglected to evaluate medium rare and very well done degrees. In addition, this study only evaluated nutritional differences in steaks with Slight (USDA Select) and Modest (USDA Choice) degrees of marbling.

Because degree of doneness is an important factor in consumer's overall acceptance of beef steaks, nutrition information should be more readily available to reflect this variable. The objective of this study was to determine the role of USDA quality grade on the nutrient composition of steaks when cooked to different degrees of doneness.

II. MATERIALS AND METHODS

Carcass and Cut Selection: Beef carcasses (n = 15) were selected from a commercial packing plant. One side from each of five USDA Prime, five USDA Choice, and five USDA Select beef carcasses was fabricated, and IMPS 180 Beef Loin, Strip Loin, Boneless *[9]* subprimals were obtained, vacuum packaged, boxed, and shipped to Texas A&M University for fabrication into retail cuts.

Retail Cut Fabrication: After aging for 14 d, each strip loin was further processed into a minimum of ten top loin steaks (2.54 cm thick) with no more than 0.64 cm external fat. Each steak was labeled individually, vacuum packaged, and frozen at −40°C for subsequent cooking and dissection.

Cooking: Steaks were assigned randomly to one of five degrees of doneness, ensuring that each subprimal had two steaks allocated to each treatment. Steaks were thawed overnight in a cooler (4 ± 2ºC), weighed, and cooked. Cooking endpoints were based on the "Beef Steak Color Guide: Degrees of Doneness" *[8]* and are described as raw (uncooked), medium rare (63°C), medium (71°C), well done (77°C), and very well done (82°C). Steaks were cooked using clam-shell-style grills. Temperature of each steak was monitored using a digital, hand-held thermometer with a type K thermocouple inserted into the geometric center of the steak. After reaching appropriate endpoint temperature, steaks were removed from the grill, placed on a nonabsorbent plate, and allowed to rest for five min before weighing. After cooking, the steaks were chilled overnight in a cooler (4 ± 2ºC).

Sample Preparation: Both raw and cooked steaks were dissected into separable lean, separable fat, and waste. Separable lean included all muscle, intramuscular fat, and any connective tissue that was considered edible. Separable fat consisted of external and seam fat. Refuse included any heavy connective tissue that was considered inedible. Proximate analyses were performed on separable lean only.

There were two steaks from each strip loin cooked to the same degree of doneness. Equal portions of the separable lean components from each steak were combined in Ziploc® bags and were held in a cooler (4 ± 2ºC) for same-day homogenization. Bagged samples were removed from refrigeration one at a time, and the separable lean was cubed (≤ 2.5 cm^3 pieces) and placed in an insulated foam nitrogen bucket (approx. 1.89 L) containing liquid nitrogen. Samples were stirred to ensure that all pieces were thoroughly frozen. Using a stainless steel strainer, the frozen samples were transferred into a Robot Coupe BLIXER 6V. Each sample was blended for approximately 10 s on low speed (1500 rpm) and 30 s on high speed (3500 rpm), after which a small amount of liquid nitrogen was added to the sample before a second homogenization began. Once the sample was completely homogenized, 60 g was removed for proximate analysis and 100 g for proximate backup. Samples were double bagged and stored in a freezer until further analysis.

Moisture Analysis: Moisture analysis was performed using the oven-drying method 950.46 *[2]*. Five-gram samples were weighed in triplicate in pre-labeled, pre-dried, pre-weighed aluminum dishes and allowed to dry for 16 to 18 h at 100°C in a Fisher Scientific Isotemp 650G Lab Oven. Following drying, samples were removed, placed in a Nalgene dessicator, and weighed for the calculation of percentage moisture.

Ash analysis: Ash was determined using the ash oven method 942.05 *[2]*. The samples remaining from the moisture analysis were placed into a box furnace at 600°C for 10.5 h and then were held at 100°C until samples were removed. Samples were placed in a Nalgene dessicator and weighed to determine percentage ash.

Lipids: Lipid was extracted using the modified Folch et al. *[3]* method. Approximately 0.5 g of each sample was weighed in triplicate and combined with 15 mL chloroform:methanol (2:1) in a 55 mL screw-top culture tube. Tubes were shaken for 10 min to extract lipids. The homogenate was filtered through a Buchner funnel into a 55 mL screw-top culture tube. Eight mL of a 0.74% KC1 solution was added to each sample tube and the sample was vortexed for 30 s. The sample was transferred to a 50 mL graduated cylinder, covered with parafilm, and stored for at least 12 h. The total volume of the chloroform:methanol layer was recorded. After separation, the KCl layer was siphoned off, and 10 mL of the lower phase was transferred into a pre-labeled, pre-weighed vial. The sample then was evaporated with nitrogen using the N-Evap. After evaporation, the vials were placed in a drying oven at a temperature of 100 °C for ~10 min to remove any moisture left from the evaporation bath and the final vial weight was recorded.

Protein Analysis: Percent protein determination was performed by combustion using a rapid N cube nitrogen analyzer. Standard blank and calibration procedures were performed in accordance with the operators' instruction manual. Analysis was performed in triplicate with approximately 250 mg of each sample being placed into foil weigh boats followed by compression to form pellets. Pellets were weighed, placed in the nitrogen analyzer carousel, and analyzed. Percent nitrogen was determined by multiplying the nitrogen percent by 6.25.

Statistical analyses: Data were analyzed using JMP® Software (JMP®, Version 9.0.0, SAS Institute Inc., Cary, NC, 1989-2010). Least squares means were generated for the main effects of USDA quality grades, degree of doneness, and their interactions, and separated using the LSMeans Differences Student's t option when appropriate with an alpha-level (*P* < 0.05).

III. RESULTS AND DISCUSSION

Cooking Yields: As degree of doneness increased, cooking yield decreased (P < 0.05), which is most likely due to moisture loss during prolonged cooking. Akinwunmi et al. *[1]* showed a similar relationship between degree of doneness and cooking yield. Cooking loss differences were such that a 250 g steak cooked to medium rare would yield 22 g more than a steak of equal weight cooked to very well done.

Theoretically, steaks that had a higher intramuscular lipid content would have a greater amount of cooking loss; however, there was no relationship (P > 0.05) between grade and cooking yield. Jones et al. *[4]*, Luchak et al. *[6]*, and Wahrmund-Wyle et al. *[13]* all found no differences (P > 0.05) between USDA Choice and USDA Select percentage cook loss for beef retail cuts.

Separable Tissue Components: Grade did not (P > 0.05) influence the percentage of separable lean (data not reported in tabular form), which is consistent with the findings of Wahrmund-Wyle et al. *[13]*. USDA Select steaks had (P < 0.05) less fat and more separable refuse when compared to USDA Choice and USDA Prime steaks.

As degree of doneness increased, the percent of separable lean decreased slightly, but only very well done steaks had (P < 0.05) less separable lean. Separable fat and separable refuse were not influenced (P > 0.05) by degree of doneness.

Proximate Analyses: USDA quality grade influenced (P < 0.05) the percentage of chemical fat, moisture, protein, and ash found in top loin steaks (Table 1). Here, it is evident that fat increased as grade increased. This is expected because with an increase in USDA quality grade, there was an increase in intramuscular fat. Similarly, as grade increased, the percentage of protein decreased. USDA Choice and USDA Select steaks were similar (P > 0.05) in moisture content, whereas USDA Prime steaks were lower (P < 0.05). Furthermore, USDA Choice and USDA Prime steaks were similar (P > 0.05) in ash content.

Degree of doneness influenced (P < 0.05) the percentage of chemical fat, moisture, protein, and ash found in top loin steaks (Table 1). As the endpoint temperature increased, percent fat and protein increased. However, percent moisture generally decreased. This was because the cooking process caused a loss of moisture. In the raw counterparts, there was a greater concentration of moisture so the nutrient components of the steaks were more diluted and thus contributed to a lower percentage of the total. As expected, percentage ash was relatively constant among degrees of doneness.

Similar trends in proximate analyses for USDA quality grade and degrees of doneness were found by Akinwunmi et al. *[1]*; however, they reported higher numerical values for percent fat and lower numerical values for percent moisture. Jones et al. *[5]* also reported higher percent fat and lower percent moisture values for USDA Choice and USDA Select, but our data were more similar to those of Wahrmund-Wyle et al. *[14]* for the same grades.

Table 1 Percentage chemical fat, moisture, protein, and ash

	Percentage			
Item	Fat	Moisture	Protein	Ash
USDA quality grade[a]				
Prime	14.8a	60.0a	24.9a	1.10a
Choice	7.9b	66.0b	26.3b	1.16a
Select	5.4c	67.0b	27.7c	1.24b
SEM	0.3	0.4	0.2	0.02
Degree of doneness[b]				
Raw	7.3a	70.1a	22.3a	1.12a
Medium rare	9.6b	64.7b	25.8b	1.14a
Medium	9.9b	63.4bc	26.8c	1.14a
Well done	9.8b	62.2cd	27.9d	1.20ab
Very well done	10.0b	61.2d	28.6e	1.24b
SEM	0.4	0.5	0.2	0.02

Means within the same column and the same main effect lacking a common letter (a–e) differ (P < 0.05).
[a] U.S. Department of Agriculture *[10]*.
[b] Degrees of doneness follow the "Beef Steak Color Guide" *[8]*and are described as rare (60°C or less), medium rare (63°C), medium (71°C), well done (77°C), and very well done (82°C).

Caloric Values: Table 2 depicts caloric values using Atwater conversions *[7]*. As USDA quality grade increased, the caloric value increased due primarily to a higher percentage of fat (Table 2). There was a 46.1% increase in caloric values between USDA Select and USDA Prime steaks, which could have a major impact on recommended daily total fat and energy intake. Similarly, as steaks were cooked to a higher endpoint temperature, the caloric value increased. There was a 9.0% increase in caloric values between medium rare and very well done steaks. For every increase in a degree of doneness, there was ~18 kJ increase in a 100g edible portion. These data clearly indicate that degree of doneness and USDA quality grade play important roles in the ultimate caloric value in top loin steaks.

Table 2 Caloric values of beef top loin steaks

	Kilojoules per 100 grams		
Item	Fat	Protein	Total
USDA quality grade[a]			
Prime	557.0a	416.2a	973.2a
Choice	298.4b	440.7b	739.2b
Select	202.7c	463.5c	666.2c
SEM	12.4	2.9	12.4
Degree of doneness[b]			
Raw	275.2a	373.8a	648.9a
Medium rare	360.6b	432.7b	793.3ab
Medium	374.2b	448.6c	822.9ab
Well done	367.7b	466.8d	834.5b
Very well done	385.9b	478.8e	864.7c
SEM	16.0	3.8	16.0

Means within the same column and the same main effect lacking a common letter (a–e) differ ($P < 0.05$).
[a] U.S. Department of Agriculture *[10]*.
[b] Degrees of doneness follow the "Beef Steak Color Guide" *[8]* and are described as rare (60°C or less), medium rare (63°C), medium (71°C), well done (77°C), and very well done (82°C).

IV. CONCLUSIONS

As the degree of doneness increased, percent fat and protein increased, which impacted the caloric value of individual steaks. Differences in caloric values based on degree of doneness should be a component of the USDA National Nutrient Database for Standard Reference.

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REFERENCES

1. Akinwunmi I, Thompson LD, Ramsey CB (1993) Marbling, fat trim and doneness effects on sensory attributes, cooking loss and composition of cooked beef steaks. J Food Sci 58:242-244 DOI 10.1111/j.1365-2621.1993.tb04247.x
2. AOAC International (1990) Official methods of analysis. AOAC, Arlington, VA
3. Folch J, Lees M, Sloane Stanley GH (1957) A simple method for the isolation and purification of total lipides from animal tissues. J Biol Chem 226:497-509
4. Jones DK, Savell JW, Cross HR (1992) Effects of fat trim on the composition of beef retail cuts — 3. Cooking yields and fat retention of the separable lean. J Muscle Foods 3:73-81
5. Jones DK, Savell JW, Cross HR (1992) Effects of fat trim on the composition of beef retail cuts — 2. Fat and moisture content of the separable lean. J Muscle Foods 3:57-71
6. Luchak GL, Miller RK, Belk KE et al. (1998) Determination of sensory, chemical and cooking characteristics of retail beef cuts differing in intramuscular and external fat. Meat Sci 50:55-72
7. Maynard LA (1944) The Atwater system of calculating the caloric value of diets. J Nutr 28:443-452
8. National Cattlemen's Beef Association (1998) Beef steak color guide: degrees of doneness. Item No. 06-404. National Cattlemen's Beef Association, Research and Knowledge Management, Centennial, Colorado
9. North American Meat Processors Association (2010) The meat buyer's guide™. North American Meat Processors Association, Reston, VA
10. U.S. Department of Agriculture (1997) United States standards for grades of carcass beef at http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3002979
11. U.S. Department of Agriculture (2009) Nutrient data set for retail beef cuts at http://www.ars.usda.gov/Services/docs.htm?docid=18961
12. U.S. Department of Agriculture (2010) 9 CFR Parts 317 and 381, Nutrition labeling of single-ingredient products and ground or chopped meat and poultry products; final rule at http://edocket.access.gpo.gov/2010/pdf/2010-32485.pdf
13. Wahrmund-Wyle JL, Harris KB, Savell JW (2000) Beef retail cut composition: 1. Separable tissue components. J Food Compos Anal 13:233-242
14. Wahrmund-Wyle JL, Harris KB, Savell JW (2000) Beef retail cut composition: 2. Proximate analysis. J Food Compos Anal 13:243-251