EFFECT OF MEAT TYPE AND COOKING METHOD ON COOKING YIELDS

Janet M. Roseland, Juhi R. Williams, Marybeth Duvall, Bethany Showell, Kristine Y. Patterson, Juliette C. Howe (Consultant) and Joanne M. Holden

Nutrient Data Laboratory, Agriculture Research Service, United States Department of Agriculture, Beltsville, MD, USA

Abstract-- USDA cooking yields for foods serve as an important resource for US and international food composition databases. The Nutrient Data Laboratory (NDL) conducted several collaborative research studies with scientists in the food industry and universities to update values on cooking yields in meat products. This report contains results from multiple studies on the effects of meat type, cooking method, and product fat content on cooking yield, moisture and fat retentions. Samples were chosen according to statistical sampling plans designed to provide nationally representative data. Standard procedures were developed for cooking, handling, and weighing of all samples. Cooking yields were calculated from raw and final cooked weights, and moisture and fat content were determined. Cooking yields for comparable beef and pork cuts varied according to cooking method used. Fat content of ground beef significantly impacted cooking yields; cooking yields were inversely related to fat levels in the products studied. The yield data in this study will be included in USDA tables for meat cooking yields. USDA yield data provide researchers, nutrition professionals, industry officials, and consumers with important information for reference, and for making decisions regarding food plans and food preparation.

Key Words – fat, moisture, nutrient data

I. INTRODUCTION

The Nutrient Data Laboratory (NDL) at the USDA conducts food composition research to develop accurate, unbiased, and representative food and nutrient composition data, which are released electronically on the NDL web site as the USDA National Nutrient Database for Standard Reference (SR) at *http://www.ars.usda.gov/nutrientdata*. SR is used as the foundation of most other food composition databases and related applications in the U.S. and worldwide to monitor food and nutrient intake, to conduct human nutrition research, to label foods, and to develop nutrition policy. USDA food composition data support efforts of the USDA Food Safety and Information Service (FSIS) and those of the retail meat industry to initiate single ingredient meat labeling [1], which became mandatory in March 2012.

Since the 1950's, USDA has also released cooking yield tables that describe changes in food weight due to moisture loss (e.g. evaporation, moisture drip), water absorption (e.g. boiling), or fat gains/losses during food preparation and cooking. Cooking yields are used in food formulations and recipes to convert nutrient values for uncooked foods into values for cooked foods. NDL has conducted several collaborative studies with scientists in the meat industry and universities to update values on cooking yields in meat products. These data are used in conjunction with nutrient data to develop nutrient retention values for moisture, fat, vitamins and minerals. This report contains results from multiple studies on the effects of meat type, cooking method, and product fat content on cooking yield, moisture and fat changes.

II. MATERIALS AND METHODS

Samples in this study were chosen according to statistical sampling plans designed to provide nationally representative data. Pork cuts and ground beef samples were purchased from 12 to 24 retail outlets nationwide using the sampling plan developed for the National Food and Nutrient Analysis Program (Pehrsson et al. [2]; Perry et al. [3]). For beef cuts, ground pork and game meats, samples were obtained from US commercial processing plants or US feedlots. Products for these studies were obtained from major suppliers for each meat source.

Standard procedures were developed for cooking, standing time, handling, and weighing of all samples. All cuts, both raw and cooked, were carefully prepared for cooking. To achieve uniform sizing for meat patties, 112 g of ground meat were pressed into a patty mold.

Total weights of each sample (0.1 g), both raw and cooked (prior to and after cooking), were obtained. Meats were cooked according to cooking guidelines developed by the meat industry. Internal temperature of each sample was monitored and recorded using a thermocouple or electronic digital thermometer placed in the geometric center or thickest portion of each cut. Samples were allowed to stand while monitoring the rise in internal temperature until temperature began to decline. The highest temperature reached was considered the final internal temperature for that sample. Final temperatures attained and oven temperatures are listed in Table 1.

Pork blade chops were grilled on a pre-heated electric barbeque grill for 10 minutes, then removed from the grill and monitored until a final internal temperature was attained.

Beef pot roasts were placed in a pre-heated pan for "browning/searing", turning as needed for even browning; pan drippings were poured off and the volume (mL) of drippings was measured. A small amount of distilled, de-ionized water was added. The pan was covered tightly. The beef samples were simmered in a preheated 250°F oven, till a final temperature was attained. The beef samples were removed from the cooking liquid and the cooking liquid yield and volume were documented.

Pork shoulders were placed on a rack in a roasting pan for braising. Distilled water (100 ml) was added to the roasting pan, which was covered tightly and placed in a preheated 325º F oven. Cuts were braised until reasonably tender.

Table 1 Effects of cooking on cooking yields, moisture and fat retention in beef and pork cuts, and ground products

Cuts	Cooking Method[1] (Oven Temp) / Final Temperature	% Cooking Yield	n	SD	% Moisture Change	% Fat Change
Beef, shoulder pot roast, boneless, trimmed to 0" fat, all grades	Braised (250°F) / 85°C	66	70	6.2	-32.0	-1.1
Pork, fresh, shoulder, Boston butt, blade steaks	Braised (325°F)/85°C	65	11	3.1	-36.5	+3.09
Beef, rib eye steak, bone-in, lip-on, trimmed to 1/8" fat, all grades	Broiled / 70°C	86	36	4.0	-17.4	-0.3
Pork, fresh, loin, bone-in, blade chops	Broiled / 71°C	83	12	3.1	-18.5	+2.14
Beef, rib eye roast, bone-in trimmed to 1/8" fat, all grades	Roasted (325°F) / 60°C	75	35	2.8	-21.8	-2.6
Pork, fresh, loin, bone-in, center loin roast	Roasted (425°F) / 71°C	77	12	6.38	-24.4	+2.41
Ground products						
Beef, ground, patty, high fat (>22% fat)	Broiled / 71°C	63	4	2.6	-24.2	-12.0
Pork, ground, patty, high fat (>27% fat)	Broiled / 74°C	69	4	3.1	-25.3	-6.64
Beef, ground, patty, medium fat (12%-22% fat)	Broiled / 71°C	69	4	3.9	-25.1	-5.2
Pork, ground, patty, medium fat (10%-27% fat)	Broiled / 74°C	68	4	1.6	-26.7	-1.91
Beef, ground, patty low fat (<12% fat)	Broiled / 71°C	73	4	0.9	-24.2	-1.6
Pork, ground, patty, low fat (<10% fat)	Broiled / 74°C	68	4	2.5	-32.7	0.18
Elk, ground (8.7% fat)	Broiled / 71°C	84	5	3.7	-15.0	-1.5
Emu, ground (4.6% fat)	Broiled / 71°C	80	6	6.8	-20.2	-0.2
Bison, ground (15% fat)	Broiled / 71°C	77	6	1.3	-18.2	-4.2
Ostrich, ground (7.1% fat)	Broiled / 71°C	86	6	2.5	-13.5	-2.7
Deer, ground (8.2% fat)	Broiled / 71°C	83	3	1.9	-17.7	-0.1

[1]Broiled refers to both broiled and grilled

Cooking time was determined from initial trials. Initial cooking time estimate was 45 minutes. Immediately after removal from the oven, the product was placed on a wire rack. Cuts were allowed to cool for 5 minutes at room temperature and then weighed.

Cuts assigned to roasting were placed in a conventional oven preheated to 325°F for beef rib eye roast, and 425°F for pork center loin roast. No oil or water was added, and the pan was not covered.

Raw and cooked meat samples were prepared and chemically analyzed for moisture and total fat. Moisture content was determined using AOAC method 950.46 [4]. Fat was determined using the acid hydrolysis method (AOAC 954.02 [4]) or chloroform/methanol method (Folch et al. [5]). Quality control was assured through the use of standard reference materials and in-house control materials.

Cooking yields were calculated from the initial (raw) and final cooked (ckd) weights according to the following formula:

$$Yield\ \% = \frac{\text{Cooked sample ckd weight}}{\text{Cooked sample raw weight}} \times 100$$

In addition to cooking yield, the % moisture change (retention) and % fat change (retention) were calculated. The change in nutrient content between raw and cooked products was used to estimate moisture loss and fat loss during cooking. The following equation was used to calculate % moisture change:

$$\frac{\frac{g\ water}{100g\ ckd\ meat} \times g\ ckd\ meat - \frac{g\ water}{100g\ raw\ meat} \times g\ raw\ meat}{g\ raw\ meat} \times 100$$

The equation used for % fat change was the same as above, except substituting fat values for water values. This percent change for moisture or fat could be positive or negative, indicating a gain or loss, respectively.

Means and frequencies were used to test the statistical significance of differences in cooking yields due to meat source, cooking methods, and product fat category (high, medium, and low). Independent samples t-tests were used to determine if mean differences in yield due to meat source were statistically significant. One-way analysis of variance (ANOVA) was used to evaluate the effects of cooking method on cooking yields. To adjust for pair-wise differences, Tukey's HSD method was incorporated in the analysis. Factorial ANOVA was used to determine mean differences simultaneously between meat sources and cooking method. For ground products, one-way ANOVA was utilized to compare: the effect of fat content in ground beef and pork on cooking yields; the effect of meat source on cooking yields.

III. RESULTS AND DISCUSSION

Cooking yields for comparable beef and pork cuts varied according to cooking method used. Broiling resulted in the highest yields; braising produced the lowest yields ($p<0.0001$, Table 2). No significant differences in yields were found when comparing beef and pork ($p=0.2794$). Regardless of cooking method, pork cuts had a slight increase in fat content. Beef cuts, however, demonstrated a small fat loss regardless of cooking method. Pork cuts had slightly higher moisture loss than beef cuts (Table 1).

Table 2 Effects of cooking on cooking yields in beef and pork cuts

		Yield Mean (SD)	P-value
Meat	Beef	73.34 (9.68)	0.2794
	Pork	75.29 (8.68)	
Cooking Method	Braised	65.86 (5.87)^{b}	<0.0001
	Broiled	85.25 (3.99)^{c}	
	Roasted	75.51 (4.04)^{d}	

Yield values with similar superscripts within a column are not significantly different at $p<0.05$.

Fat content of the ground beef significantly impacted cooking yields; cooking yields were inversely related to fat levels in the products studied ($p<0.0128$, Table 3). No significant differences in ground pork yields were seen among the 3 fat levels.

Table 3 Bivariable analysis of mean yield by fat content in ground beef and pork

		Yield[1] Mean (SD)	P-value
Beef, ground, broiled	High Fat (>22%)	63.0 (2.6)[a]	<0.0128
	Med Fat (12-22%)	69.0 (3.9)[a]	
	Low Fat (<12%)	73.0 (0.9)[b]	
Pork, ground, broiled	High Fat (>27%)	69.0 (3.1)	0.2310
	Med Fat (10-27%)	68.0 (1.6)	
	Low Fat (<10%)	68.0 (2.5)	

Statistical significance was determined by one-way ANOVA; critical value was set at p<0.05.
[1]Yield values with similar superscripts within a column are not significantly different at p<0.05.

Statistical evaluation by ANOVA determined that comparison of cooking yields across all fat categories for beef and pork failed to reach significance overall (p = 0.0507). Among 7 types of ground meats, ostrich had the highest yield (86%). Ground pork had the lowest yield (68%), which was significantly different than the yields for all the other ground meat sources (p<0.0001), except ground beef (Table 4).

Table 4 Analysis of Variance (ANOVA) for ground meat yields ($R^2 = 0.85$) P <0.0001

Ground Meat Type	Yield Mean	SD
Beef	73.0[cd]	0.90
Pork	68.0[d]	2.50
Elk	84.0[a]	3.70
Emu	80.0[abc]	6.80
Bison	77.0b[c]	1.30
Ostrich	86.0[a]	2.50
Deer	83.0[ab]	1.90

Statistical significance was determined by one-way ANOVA; critical value was set at p<0.05.
[1]Yield values with similar superscripts within a column are not significantly different at p<0.05.

IV. CONCLUSION

Yield data provide valuable information regarding the impact of factors such as cooking methods, meat type, and fat content on total cooking yield as well as moisture and fat retention. The yield data in this study will be included in USDA tables for meat cooking yields. USDA yield data provide researchers, nutrition professionals, industry officials, and consumers with important information and for making decisions regarding food plans and food preparation.

ACKNOWLEDGEMENTS

The authors recognize Larry Douglass for his valuable knowledge for sampling plans and statistical evaluation. We thank the National Cattlemen's Beef Association, National Pork Board, meat scientists and students at Colorado State University, Texas A & M University, Texas Tech University, and University of Wisconsin, and Phil Lofgren for their involvement in these studies. Thanks to Marlon Daniel at USDA/NDL for statistical analysis of these data.

REFERENCES

1. Code of Federal Regulations (2003). Animals and Animal Products; U.S. Department of Agriculture; Food Safety and Inspection Service, Meat and Poultry Inspection, Definitions and Standards of Identity. 9 CFR 319.

2. Pehrsson, P. R., Haytowitz, D.B., Holden, J.M., Perry, C.R. and Beckler, D.G. (2000) USDA's National Food and Nutrient Analysis Program: food sampling. Journal of Food Composition and Analysis 13:379-389.

3. Perry C.R., Pehrsson P.R., and Holden J. (2003). A revised sampling plan for obtaining food products for nutrient analysis for the USDA National Nutrient Database. Proceedings of the American Statistical Association, Section on Survey Research Methods [CD-ROM], Alexandria, VA: American Statistical Association, San Francisco.

4. Official Methods of Analysis of AOAC International (2000) 17th Ed., AOAC International, Gaithersburg, MD.

5. Folch, J., Lees, M. and Stanley, G.H.S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry 226: 497-509.