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Comparison of palatability characteristics of rib eye steaks, by grades, cooked by conventional oven broiling and microwave cookery.

CHOUN, H.S., KINSMAN, D.M., HALL, K.N. and HOAGLAND, T.A.
University of Connecticut, Storrs, Connecticut, USA 06268

Microwave energy has been used for the cooking and heating of foods over more than three decades. Microwave oven cooking is popular for both large scale institution use and home use.

The effects of microwave cooking on eating quality of meat have been widely studied with respect to whether it is comparable to conventional cooking. The major parameters in comparison of microwave cookery versus conventional methods of cookery on meat quality are cooking time, cooking loss, shear value, and palatability factors, such as tenderness, juiciness and flavor.

Early studies indicated that the resulting quality of most meats cooked by microwaves was less desirable than that of meat cooked by conventional method. (Headley and Jacobson, 1960; Marshall, 1960; Kylen et al., 1964).

With advancement of microwave oven design, such as power level controller, and rotating devices, recent studies have shown a trend that the quality of some meats cooked by microwaves compare favorably to that of meat cooked by conventional methods (Baldwin et al., 1979; Voris and Van Duyne, 1979; Moore et al., 1980; Fulton and Davis, 1983).

The present study was conducted to determine the effects of two cooking methods, microwave and conventional cookery, on meat quality of beef rib eye steaks by three grades. The three grades: USDA Prime, Choice and Good were used because they are the most popular for fresh meat at the retail market. Cooking loss and shear value were measured as physical parameters, and sensory evaluation was conducted to obtain palatability characteristics.

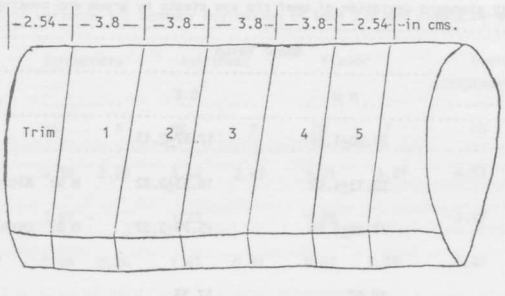
SOURCE OF MATERIALS Three grades of beef, USDA Prime, Choice and Good, were used for sensory evaluation, cooking loss, Warner-Bratzler shear value measurements and proximate analysis. Six boneless rib eye rolls (USDA-Institutional Meat Purchase Specifications, 112A-rib eye roll, lip-on) of each grade were obtained from Iowa Beef Processors (IBP), Dakota City, Nebraska.

Each rib eye roll was divided into five slices as shown in Figure 1. Slices No. 1 through No. 4 were 3.81 cm thick and slice No. 5 was 2.54 cm thick. The selection of steaks for each experiment was designed to provide consistent and paired adjacent portions which were considered to be similar in composition. Steaks for sensory evaluation (Nos. 1 and 2) and for cooking loss and shear value measurements (Nos. 3 and 4) and for proximate analysis, (No. 5) were wrapped in freezer paper. All steaks were frozen and stored at -28.9 C for ten to thirty days until needed for further testing. Prior to cooking, the wrapped steaks were defrosted at a refrigerator temperature of 1.1 C for 48 hours.

COOKING TREATMENT Four steaks, two pairs from two rib eye rolls were chosen randomly for cooking for each sensory evaluation session. The number 1 steaks were cooked in the microwave oven and the number 2 steaks were cooked in the conventional oven. All steaks were removed from the refrigerator and held at ambient temperature for approximately one hour to reach a temperature of 10 to 12.8 C and then weighed before cooking.

Steaks cooked by conventional oven broiling were placed in a broiler pan in a General Electric household electric oven preheated at broiling setting of 260 C. Thermocouples connected to a recording potentiometer were used to monitor the oven temperature, initial temperature of steaks, and the internal temperature of the steaks during and after cooking. All the thermocouples were inserted into the approximate geometric center of the steaks. Two steaks with thermocouples inserted were placed into the oven 7.62 cm below the heat source and the oven door left ajar. After 10 minutes broiling, the steaks were turned over and then allowed to reach the internal temperature of 68.3 C. The mean cooking time in the conventional oven was 25 minutes and 15 seconds with a range of 19 minutes to 32 minutes. The steaks were removed from the oven and cored with a 1.27 cm diameter mechanical stopper boring device to reduce "Hour Glass" effect of hand coring. One core was given to each panel member for sensory evaluation.

For each sensory evaluation session, two steaks were cooked in the microwave oven at the high power setting (650 watts, 2450 MHz, Whirlpool, Model RJM7800). Thermocouples were inserted into the steaks in the same manner as described above, in order to record the initial temperature of the meat.



1. Steak cooked in microwave oven for sensory evaluation.
2. Steak cooked in conventional oven broiling for sensory evaluation.
3. Steak cooked in microwave oven for cooking loss and shear value.
4. Steak cooked in conventional oven for cooking loss and shear value.
5. Steak for proximate analysis.

Figure 1. Schematic drawing of slicing plan for steaks from rib eye roll.

After removal of the thermocouples, the steaks were placed in a round plastic microwave meat rack on a device that rotates at a rate of one revolution per 111 seconds per round to minimize uneven cooking. The rotating device was placed in the center of the microwave oven and the steaks off center. The method of cooking was as described in the book, "Microwaving Meat," published by Microwave Cooking Library (1979). The steaks were heated in the microwave oven for 2 minutes for one side, and then turned over. Glass microwave thermometers were inserted in the center of the steaks while avoiding any portion of fat. When the thermometer indicated the internal temperature of 68.3 C, the steaks were removed from the oven and the internal temperature was re-checked immediately with thermocouples. The mean cooking time in the microwave oven was 11 minutes and 5 seconds with a range of 8 minutes to 14 minutes and 20 seconds. The steaks were then cored with a 1.27 cm diameter mechanical stopper boring device and served without delay. Four steaks from two different rib eye rolls were cooked at each cooking session for the determination of cooking loss and shear value. These steaks were cooked by the same method as the steaks for sensory evaluation.

COOKING LOSS AND SHEAR MEASUREMENTS After the internal temperature of the steak reached a temperature of 68.3 C, the steaks were removed from the oven and its outer side was dried with a paper towel to remove any excessive drip, followed by weighing to determine total cooking loss by difference. The shear force of the cooked steak was measured by a Warner-Bratzler shear. The steaks were cooled for approximately one hour to reach a temperature of 10 to 12.8 C and a 2.54 cm diameter core was removed from dorsal, medial and lateral positions of each steak. Three measurements with the Warner-Bratzler shear were made on each core and the shear value was obtained by averaging these nine measurements.

SENSORY EVALUATION Tenderness, juiciness, flavor and overall acceptability of steak cores were evaluated by a 10-member, untrained panel. A 1-to 8-point hedonic scale (1-extremely tender, juicy, flavorful, or like, and 8 = extremely tough, dry, lacking flavor, or dislike) was employed for subjective evaluation. The cooked steaks were cored and served immediately after cooking was done. Sensory evaluation was completed within 15 minutes after cooking was done. The sensory samples were coded for evaluation identification by three digit numbers selected from a table of random numbers. A panelist received samples from the same locational area of each steak in the same sensory panel booth during the entire experiment.

The panelists were not informed of the cooking method for the samples provided. The panelist had one slice of apple and water for palate cleaning between the evaluation of each core. The general information on the cooking and sensory evaluation procedures used in this study were obtained from the book, "Guidelines for Cookery Sensory Evaluation of Meat" (Cross et al., 1978). Sensory evaluation score was obtained by averaging ten scores from ten panelists.

PROXIMATE ANALYSIS One raw steak from each rib eye roll (2.54 cm thickness) was sent to the Connecticut Agricultural Experiment Station at New Haven for proximate analysis; moisture, protein, fat and ash to characterize the composition of the raw steaks by grade.

STATISTICAL ANALYSIS Means and standard deviations of cooking loss, shear value and sensory evaluation were determined. The data were analyzed for differences due to cooking method and grade using analysis of variance by the method described by Snedecor (1956) and Henderson (1960).

RESULTS:

COOKING LOSS Mean cooking loss, Warner-Bratzler shear value, and analysis of variance for rib eye steaks, by grade and by cooking method, are presented in Tables 1 and 2. Mean cooking loss for steaks of all grades cooked by microwave oven was found to be 3.03% greater than that for steaks cooked by conventional oven broiling. This difference was statistically significant ($p < 0.05$). No significant differences were found in cooking losses for the steaks among the three grades cooked either by microwave or conventional oven broiling. This result indicates that the cooking loss of the steaks was affected more by cooking method than by grade of meat. Microwave energy causes molecules in the meat to vibrate at a very high frequency. Possibly the vibration accelerates the rate of migration of moisture and fat from the inner portions of the meat to the surface. This would likely increase the amount of drip and evaporation. There was no significant interaction between cooking method and grade.

Table 1. Mean cooking loss and shear value with standard deviation of beef rib eye steaks by grade and cooking method.

Grade	Cooking loss (%)		Shear Value	
	M W	O B	M W	O B
Prime	27.71±2.94	25.14±2.54	20.20±1.84	17.87±2.13
Choice	28.16±2.09	24.23±3.24	22.13±4.42	18.33±2.82
Good	28.18±1.81	25.60±4.62	17.29±1.29	15.79±3.37
Mean of all grades	28.02	24.99	19.87	17.33

M W: Microwave
O B: Oven Broiling

Table 2. Analysis of variance for cooking loss and shear value of beef rib eye steaks by grade and cooking method.

Source	df	Cooking Loss		Shear Value	
		MS	F-value	MS	F-Value
Cooking	1	82.39	7.93 *	58.15	4.53 *
Steaks/G	15	10.39		12.83	
Grade	2	1.5	0.19	42.42	12.19 **
Cooking x Grade	2	1.81	0.22	4.07	1.17
Cooking x Steak/G	15	8.10		3.48	
Total	35				

*: $p < .05$
**: $p < .01$
df: degree of freedom
MS: mean square

SHEAR VALUE Steaks of all grades cooked in the microwave oven were found to have a mean Warner-Bratzler shear value of 2.54 higher ($p< 0.05$) than that of steaks cooked by conventional oven broiling. The differences of shear values among the three grades were highly significant ($p< 0.01$) in both microwave and conventional cooking. The steaks of Good grade showed the least shear value, followed by Prime and Choice grades in order of increasing value. This unexpected result was possibly due to some uncontrolled variable such as the maturity of the animals from which the meats were obtained. Presumably all the meats of the three grades were from young cattle, and due to their young age, the meat of the Good grade could be as tender as that of Prime and Choice grades in spite of less marbling. All shear values were low indicating all samples were tender. There was no evidence of interaction between cooking method and grade.

SENSORY EVALUATION Means of sensory evaluation scores and analysis of variance for the rib eye steaks by grade and cooking method are listed in Tables 3 and 4. Tenderness, as measured by the taste panel, did not differ significantly by the cooking method. No significant differences were found among panel tenderness scores by grade. The tenderness scores for steaks cooked by microwave ranged between 3.54 and 4.42, representing moderately tender to slightly tender. The tenderness scores for steaks cooked by conventional oven broiling ranged between 3.52 and 3.61, which indicates moderately tender only. All steaks were tender regardless of grade. Juiciness scores did not differ significantly by cooking method even though generally steaks cooked by conventional oven broiling were more juicy than those cooked by microwaves. The juiciness scores for steaks cooked by microwave ranged between 4.09 and 5.16, representing slightly juicy to slightly dry. For steaks cooked by oven broiling, they ranged between 3.95 and 4.39 representing moderately juicy to slightly juicy. Steaks of Prime grade were shown to be most juicy, and Good grades were least juicy in both cooking methods. No significant differences were found among juiciness scores by grade.

Table 3. Mean sensory evaluation with standard deviation of beef rib eye steaks by grade and cooking method.

Grade		Tenderness	Juiciness	Flavor	Overall Acceptability
Prime	MW	3.54±1.38	4.09±0.57	4.84±0.55	4.44±0.75
	OB	3.61±1.15	3.95±1.26	4.19±1.13	3.74±1.06
Choice	MW	4.31±1.22	4.82±1.34	4.94±1.05	4.76±1.27
	OB	3.52±1.14	3.96±0.81	4.13±0.93	3.75±1.02
Good	MW	4.42±0.56	5.16±0.64	5.17±0.57	4.91±0.55
	OB	3.55±0.72	4.39±1.04	4.13±0.57	4.07±0.75

1: most desirable
8: least desirable
Note MW: microwave
OB: oven broiling

Table 4. Analysis of variance for sensory evaluation of beef rib eye steaks by grade and cooking method.

		Tenderness		Juiciness		Flavor		Overall Acceptability	
Source	df	MS	F	MS	F	MS	F	MS	F
Cooking	1	4.39	2.23	3.44	2.49	6.24	5.2*	6.53	4.44
Steak/G	15	1.97		1.38		1.20		1.47	
Grade	2	0.08	0.24	1.63	0.31	0.07	0.39	0.49	1.96
Cooking x Grade	2	0.17	0.5	0.30	0.06	0.11	0.61	0.08	0.32
Cooking x Steak/G	15	0.34		5.20		0.18		0.25	
Total	35								

*: $p< .05$
MS: mean square
F: F-value

In terms of flavor, steaks cooked by conventional oven broiling were found to be significantly more desirable ($p< 0.05$) than those cooked by microwaves. Browning of the surface of the conventionally cooked steaks is possibly responsible for the difference in flavor, while microwave-cooked steaks lacked this browning. Flavor scores of the cooked steaks among the grades did not differ significantly. The flavor scores for steaks cooked by microwave ranged between 4.84 and 5.17, indicating slightly flavorful to slightly lacking in flavor. Steaks cooked by oven broiling, ranged between 4.13 and 4.19, representing slightly flavorful. In spite of significant differences in flavor scores between steaks cooked by microwave and conventional oven broiling, overall acceptability of the steaks did not differ significantly at $p < 0.05$ either by cooking method or by grade. Even though it was not significant at $p < 0.05$, there was strong evidence that steaks cooked by oven broiling had more desirable overall acceptability than steaks cooked by microwaves. Steaks cooked in the microwave oven did not develop as attractive a brown outer surface as did those cooked in the conventional oven. The steaks cooked in the microwave oven on the automatic food rotator appeared more uniformly cooked than the steaks cooked in the conventional oven, as the interior and exterior color of the steaks looked similar. In contrast, conventionally cooked steaks had a brown exterior and a pinkish interior color. There were no significant interactions between cooking method and grade for sensory evaluation.

These experiments indicated that the palatability of beef rib eye steaks cooked in the microwave oven can be compared favorably to steaks cooked by conventional oven broiling. Cooking loss and palatability were not influenced by grade. For the top three USDA grades, Prime, Choice and Good, sensory evaluation scores of rib eye steaks did not differ significantly even though generally the higher grade was more desirable. Fresh meat at the retail market comes from young animals generally less than 24 months of age. Due to the highly acceptable tenderness of such young cattle, the effect of marbling on tenderness and other palatability factors is relatively less important than it would be with mature cattle. This study suggests that the palatability of rib eye steaks among the top three grades is similar.

PROXIMATE ANALYSIS The mean percentages with standard deviations for total protein, total water, fat and ash are listed in Table 5. There was no difference for protein or water percentages of the steaks by grade. The average protein, water and fat contents were 21.21%, 64.70% and 12.31%, respectively. As would be expected, Prime grade had the highest fat content (13.55%), followed by Choice grade (12.2%) and Good grade (10.63%), which is a reflection of degree of marbling within each grade. This difference of fat contents was not significant.

Table 5. Means with standard deviations for proximate analysis of rib eye steaks by grade.

Grade	Protein, %	Water, %	Fat, %	Ash, %
Prime	21.95±1.26	63.88±4.84	13.55±6.18	0.94±0.29
Choice	20.68±2.18	65.30±3.78	12.20±4.80	0.92±0.06
Good	21.80±1.79	64.93±1.21	10.63±1.72	0.94±0.05
Average	21.21	64.70	12.31	0.93

SUMMARY Cooking loss, Warner-Bratzler shear value and sensory evaluation of beef rib eye steaks were compared by method of cooking and by grade. Beef rib eye steaks from USDA,Prime, Choice, and Good grades were cooked by microwaves on an automatic food rotator at full power, 650 watts and by conventional oven broiling. All steaks were cooked until the internal temperature of meat reached 68.3 C. Cooking loss was determined by measuring the weight difference of a steak before and after cooking. 1.27 cm diameter cores of the cooked steaks were served to ten panelists for sensory evaluation, and cores with 2.54 cm diameter were tested for Warner-Bratzler shear force.

Mean cooking losses were significantly ($p<0.05$) greater for steaks cooked by microwaves than those for steaks cooked by conventional oven broiling in all three grades. There were no significant differences observed in cooking loss among the three grades for microwave cooking or conventional cooking. Mean shear values of steaks cooked in the microwave oven were significantly ($p<0.05$) higher than those of steaks cooked in conventional oven. The differences in shear values of cooked steaks among the three grades were highly significant ($p<0.01$) with the highest shear value for steaks of Choice grade, the second for steaks of Prime grade, and the lowest for steaks of Good grade. Shear values were low for all grades of meats and ranged from 15.79 to 22.13 indicating all meats were tender. These results are thought to be related to the maturity of animals from which the meat came. Maturity of cattle from which these rib eye rolls came is assumed to be similar. The Good grade meat which is believed to come from equally young animals was as tender as the higher grade meat, due to youth, even though the meat does not have adequate marbling to reach the U.S.D.A. Choice grade.

The flavor of steaks cooked by conventional oven broiling was significantly ($p<0.05$) more desirable than that of steaks cooked by microwaves. The flavor scores of cooked steaks did not differ significantly by grade. Tenderness, juiciness, and overall acceptability were not significantly different, according to their panel scores by cooking method or by grade. However, there was a trend that the oven broiled steaks received somewhat more desirable overall acceptability than the microwaved steaks, even though the difference was not statistically significant at $p < 0.05$. The results of this study indicate that when USDA Prime, Choice and Good grades of beef rib eye steaks are cooked by microwaves and conventional oven broiling methods, the palatability characteristics can be similar.

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