EFFECTS OF CONVENTIONAL AND MICROWAVE COOKING METHODS ON CHARACTERISTICS OF REFORMED BEEF ROASTS


SUMMARY

Comparison of conventional and microwave cooking methods were performed in this study. Reformed roasts manufactured from *Latissimus dorsi* (LD) and *Serratus Ventralis* (SV) muscles were cooked in gas ovens and in a 2450 Mhz variable power microwave oven utilizing three power levels (low, medium, and high). Cooking methods were controlled so that desired end point temperatures were achieved. The muscles were denuded of all surface fat and heavy connective tissue and were injected with abrine solution of 0.75% sodium chloride (NaCl), and 0.35% sodium tripolyphosphate (STP) and tumbled for 5 hours. Two muscles were stuffed in an impervious casing in a thick to thin fashion to attain uniform thickness and parallel fiber arrangement. Proximate analyses (moisture, fat, and protein) were performed on cooked and uncooked state. A trained panel evaluated the sensory characteristics of the roasts for juiciness, connective tissue, and tenderness. Experimental factors included: 2 roast types (SV and LD); 4 cooking methods (conventional and microwave low, medium and high power level); and 3 internal end-point temperatures 140°F, 158°F, and 167°F. Results showed no difference in cooking times between the LD and SV roasts (P < .05), but endpoint temperature was influenced by cooking method (P<.05). High and medium microwave power resulted in higher cooking loss. Cooking method and endpoint temperature were found to affect juiciness and tenderness scores; both scores decreased as endpoint temperature increased. This study suggests that adverse effects associated with microwave cooking of meat can be corrected if the endpoint temperature is controlled.

INTRODUCTION

In today's very competitive market for meat products, the beef industry must find ingenious ways to market new products. Consumers do not only demand an economically sound, quality product, but a product that is convenient, healthy and easy to prepare. In response to these consumer demands, many processors have manufactured precooked, microwavable entrees which require a reheating period. However, consumers appear to object to the high price and the occurrence of off-flavors in these ready-to-eat entrees. Perhaps a feasible alternative would be to design a portion controlled reformed beef product, manufactured for rapid microwave cooking from low valued cuts. Yates (1988) and Michaelsen et al. (1989) have documented processing procedures for the development of reformed beef roast from muscles obtained from the chuck.

The introduction of microwave cooking has opened new avenues in food preparation. With the major advantage being time saving considerations, microwave cooking fulfills the convenience attribute consumers demand by reducing cooking times. Nevertheless, microwave cooking has not been readily accepted for preparation of beef entrees, due mainly to the failure of producing an acceptable product. Uneven cooking, greater cooking losses, and less palatable meat have surrounded the mistrust in microwave cooking of meat. When compared to conventional heating methods, microwave cooking is perceived as producing a product that is less tender and less juicy. Many of these differences can be attributed to the rapid heating rates and high post-cooking temperature rise associated with microwave cooking.
The purpose of this study was to compare and evaluate microwave and conventional cooking methods when endpoint temperature is controlled. Comparison of sensory attributes of tenderness and palatability were performed on reformed roasts manufactured from the *Latissimus dorsi* (LD) and *Serratus ventralis* (SV) (Yates, 1988).

**MATERIAL AND METHODS**

*Latissimus dorsi* and *Serratus ventralis* muscles were removed from beef forequarters of USDA choice, yield grade 3 carcasses. All surface fat and connective tissue were removed. The denuded muscles were mechanically injected with a brine solution of water, salt, and phosphate. The muscles were pumped to achieve a target of 10% added water, 0.75% sodium chloride (NaCl), and 0.35% sodium tripolyphosphate (STP). The muscles were then vacuum tumbled using a cycle of 20 minutes on followed by 10 minutes of rest for a total of 5 hours. Upon completion of the tumbling cycles, two SV or LD muscles were positioned in a thick to thin fashion for stuffing to attain uniform thickness and parallel fiber arrangement. Muscles were stuffed by hand into a 4.7 in fibrous casing, utilizing a modified stuffing horn. Prior to clip sealing of the casing, each stuffed casting was placed in a vacuum/sealer to improve removal of air pockets. The casings were then clip sealed and the log frozen over night at -22°F.

Individual roasts were prepared by cutting frozen logs on a band saw to produce portions of uniform size (4.92 inches long) and shape(cylindrical), approximately 3.50 in thick, and weighing from 1.00 to 1.25 pounds. The individual roasts were vacuum packaged and kept frozen at -4°F until needed. Roast were thawed overnight prior to cooking.

The control roasts were cooked conventionally in gas ovens which were calibrated to maintain a temperature of 322°F. The meat was placed on a rack on an open pan in the oven until internal temperatures of 140°F, 158°F, and 167°F were attained. Microwave cooking was performed in a 2450 MHz variable power microwave oven with power levels of high, medium, and low. The wattage was determined by measuring temperature changes in 1000 ml of deionized water. The oven was determined to output 525 watts on high, 342 watts on medium, and 175 watts on low in the center-middle of the oven cavity. Roast cooked in the microwave were placed on a microwavable roasting tray in an open glass pan. The internal temperature of each roast were monitored using a Luxtron Fluoroptic thermometer and fiber optic probe. Regression equations were used to predict the temperature at which microwave power should be terminated in order to attain the desired final temperature. Roasts were cooked to achieve endpoint temperatures of 140°F, 158°F, and 167°F. Cooking losses were determined by weighs differences before and after cooking. After weighing, two .2 in slices were obtained from each roast and assigned for proximate analysis.

Proximate analysis was performed on both the cooked and uncooked state of the roasts. Moisture, fat, and protein were determined using methods outlined in AOAC (1980). Shear force measurements were made on 1.0 x 1.6 in sliced samples at an equilibrated temperature of 71.6°F. Samples were placed into a Kramer shear cell and the maximum force per pound required to shear through the sample was determined.

Ten trained panelists evaluated sensory characteristics for juiciness, connective tissue, and tenderness. Panel scores were based on a 8-point descriptive scale (juiciness, 1=extremely dry; 8=extremely juicy; connective tissue, 1=abundant; 8=none detected; tenderness, 1=extremely tough, 8=extremely tender). Panelists were given four samples per session and one out of the four samples was prepared conventionally. The remaining samples were prepared in the microwave at low, medium, and high power. All
samples were cooked to achieve the same endpoint temperature and served warm in preheated glass jars, held in a insulated container.

Statistical analysis was performed on experimental factors replicated three times on 2 roast types (SV and LD); 4 cooking methods (conventional and microwave low power, medium power and high power level); and 3 internal end-point temperatures 140°F, 158°F, and 167°F. All treatments effects and interactions were determined by analysis of variance for a factorial arrangements of treatments. The statistical analysis system (SAS) was used to calculate least square means, standard error and interactions.

RESULTS AND DISCUSSION

Results of the analysis on the effects of cooking times, roast type, cooking method, and endpoint temperature are presented in Figure 1. There was no difference (P > .05) in cooking times between the LD and SV muscles; however, an interaction (P < .05) of cooking method by endpoint temperature was found for this characteristic. Cooking time increases as endpoint temperature increases from 140°F to 167°F for both conventional and low power cooking methods, but there was a slight decrease in cooking time for medium and high power methods as the desired endpoint temperature increased. During conventional cooking heat moves from the surface of the roast to the interior by means of conduction. The rate at which heat moves by conduction is dependent upon the roast thermophysical properties. Not surprisingly, the conduction process is slow for meat which explains the longer cooking times observed for the conventional method. However, in the microwave oven heat is generated within the product and only has to travel a short distance to the center. Therefore, cooking time is reduced. For a well-done roast, almost two hours were required for cooking conventionally as compared to 26 minutes in the microwave, a real time savings.

There was no difference between total cooking loss of the LD and SV muscles (Table 1). However, total cooking loss was influenced by cooking method and endpoint temperature. Total cooking loss was the greatest for roast cooked by high microwave power. Medium power was intermediate in cooking loss as compared to conventional and low power which did not differ. The values presented in Table 1 are expressed as percentage of total loss. The actual percentage of cooking loss for LD and SV muscles was not different, 24% to 25.6%. An increase in wafer loss was observed for medium and high microwave power. This higher loss is believed to be related to the high internal rate of heat generation within the roasts. When compared to low power and conventional, high rate of heat generation is supported by the shorter cooking times required for medium and high power cooking (Figure 1).

Both cooking method and endpoint temperature were found to affect (P<.05) juiciness scores. However, a significant roast type by cooking method by endpoint temperature interaction was found indicating that juiciness scores are not consistent across main effects (Table 2). Juiciness scores generally decreased as endpoint temperature increased, but the decrease was not consistent with cooking method or roast type. For the LD roasts (Figure 2), conventional and low power microwave heating resulted in a decrease of juiciness scores from 140°F to 158°F, but increased for conventional and remained the same for low microwave power between 158°F to 167°F. Medium and high power microwave heating resulted in slight decrease for medium or high power from rare to medium doneness. Nevertheless, further heating to 167°F resulted in a drastic decrease in juiciness scores. The juiciness scores for the SV roasts (Figure 3) showed similar cooking method by endpoint temperature changes, except at 158°F where the values of the LD roasts at high and medium power were significantly lower.
These juiciness scores are partly related to roast composition. Chemical analysis revealed that SV roasts contained higher percentage of fat than the LD roasts. Higher presence of fat within a food product has been recognized to produce a sensation of wetness and mouth lubrication to the taster (Carpenter et al., 1966). The magnitude of the high water loss and fat for medium and high microwave power levels should influence the juiciness scores; however, the values suggested that juiciness was acceptable except when the LD roast was cooked at high or medium power to a well-done degree of doneness.

An interaction ($P < .05$) between roast and cooking method was found for tenderness scores. Figures 4 and 5 illustrate the influence of cooking method and endpoint temperature for the LD and SV roasts. As compared to the LD roasts, tenderness scores were higher for SV roasts, independently of cooking method and endpoint temperature. The tenderness scores decreased as the endpoint temperature increased as expected. However, the changes in the tenderness scores were not consistent within cooking methods and endpoint temperatures. For the SV roasts (Figure 5), the high power caused a decrease in tenderness scores from endpoint temperatures of $140^\circ F$ to $158^\circ F$, but an increase from temperatures of $158^\circ F$ to $167^\circ F$. Low microwave cooking resulted for the LD roasts in decreasing tenderness scores (Figure 4) from $140^\circ F$ to $158^\circ F$ temperatures, and increasing scores from $158^\circ F$ to $167^\circ F$. Tenderness scores for the LD roasts cooked under high power showed negligible change as the endpoint temperature increased. However, the magnitude of the tenderness scores for all cooking methods, roast type and endpoint temperature indicate acceptable palatability.

Manufacturing of reformed LD and SV roasts appears to be a feasible alternative to fulfill the demand for a convenient, easy-to-prepare, beef product. Results of this study suggest that the adverse effects of microwave cooking on the palatability and tenderness of beef products can be rectified if the endpoint temperature is controlled. Producing a product suitable for microwave cooking partly involves controlling the size, shape, and chemical composition of the roast. All these factors, which are deemed necessary for uniform microwave heating, can be controlled by reforming procedures. Microwave cooking times were less than conventional cooking regardless of microwave power levels and would undoubtedly meet the need for convenience.

**LITERATURE CITED**

TABLE 1. COOKING LOSS

<table>
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<tr>
<th>Muscle</th>
<th>Cooking Method</th>
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<td>Item</td>
<td>Conventional</td>
</tr>
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<td>Latissimus dorsi</td>
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<tr>
<td>Serratus ventralis</td>
<td>25.6</td>
</tr>
<tr>
<td>Loss (%)</td>
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<tr>
<td>H2O</td>
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</table>

*Water and fat are expressed as % of total loss.*

b,c,d Means in the same row with different superscripts are different (P < .05).

TABLE 2. SENSORY PANEL ASSESSMENT OF JUICINESS, CONNECTIVE TISSUE, AND TENDERNESS

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Cooking Method</th>
</tr>
</thead>
<tbody>
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<td>Item</td>
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</tr>
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<tr>
<td>Serratus ventralis</td>
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<td>5.6b</td>
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<tr>
<td>Connective Tissue</td>
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<td>Tenderness</td>
<td>6.0b</td>
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</tbody>
</table>

a,b,c Means within a main effect group with different superscripts are different (P < .05).

Figure 1. Effect or cooking method and endpoint temperature on total cooking time.
Figure 2. Effect of cooking method and endpoint temperature on juiciness score-LD roasts.

Figure 3. Effect of cooking method and endpoint temperature on juiciness score-SV roasts.

Figure 4. Effect of cooking method and endpoint temperature on tenderness score-LD roast.

Figure 5. Effect of cooking method and endpoint temperature on tenderness score-SV roast.