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Influence of microwave and conventional cooking and reheating on sensory and chemical characteristics of roast beef

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The sensory qualities and chemical composition of beef slices cooked and reheated in a microwave oven were compared with those of conventionally cooked and reheated samples. Sensory evaluation indicated that microwave-treated samples had higher flavour scores and were less juicy and tender than conventionally treated samples. Total moisture content was slightly higher for conventionally cooked and reheated samples as compared to microwave-cooked and reheated meat. No differences were found in the chemical composition of meat cooked or reheated by the two methods.

INTRODUCTION

Microwave ovens are widely used in food service establishments. Currently, they are used primarily for reheating. The microwave oven has high thermal efficiency in comparison with conventional gas and electric ovens. Approximately 75% less energy is required for microwave cooking or heating as compared to conventional methods (Quenzer & Burns, 1981). Ohlsson (1983) has discussed the fundamental principles of microwave cooking, while Sawyer (1983) and Bakanowski & Zoller (1984) have compared microwave and conventional heating methods.

The increase in two-working person households has increased the demand for foods that can be rapidly prepared. As a result, microwave ovens in households have increased (Boles & Parrish, 1990); the increasing popularity of microwave ovens in homes indicates that consumers are placing greater emphasis on speed and ease of meal preparation (Paterson & Parrish, 1988). Starrok & Johnson (1982) reported that an increasing number of people who own microwave ovens cook meat in them, but many are dissatisfied with the results. Precooked beef products, however, may offer beneficial alternatives to consumers who want to use microwave ovens in the preparation of meat for meals.

Beef roasts microwaved at 'simmer' were comparable with conventionally cooked roasts in sensory quality. Ang *et al.* (1975) concluded that microwave ovens, which require shorter heating times, tend to retain greater amounts of heat-labile nutrients. Sensory evaluation and chemical analysis of precooked microwaved meat produced during refrigerated storage are necessary for determining the level of palatability; for example the thiobarbituric acid (TBA) method is the most popular chemical method for measuring oxidative rancidity (Melton, 1983).

The present work was undertaken to compare the sensory and chemical characteristics of meat cooked and reheated by the microwave and conventional methods.

MATERIALS AND METHODS

Sample preparation

Boneless beef (top-round) (2 kg) was purchased from a local butcher in Alexandria. The external fat covering was removed, and the meat pieces, which weighed around 1500 g or 1000 g were cooked on a rack in an open pan of an electric oven at 170–180°C. The roasts were cut into slices of 0·8 cm thickness. The roast slices were divided into three groups. One of the groups of slices was randomly assigned to proximate analysis; the other two groups were stored at −4°C for 2 days prior to reheating treatment. After the storage period, one of the meat groups was reheated in an electric oven, while the other group of roast slices were reheated in the microwave. 500 g of meat were placed in Pyrex baking

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dishes and covered with light fitting lids; then they were cooked in a domestic Sharp microwave oven at 2450 MHz with a power setting of 550 W.

Reheating of meat

After 2 days of refrigerator (4°C) storage, the slices were reheated to attain a final internal temperature of 75°C. One group of 8–10 slices were reheated in an electric oven preheated to 160–165°C. The other 8–10 slices were reheated in the domestic microwave oven.

Sensory evaluation

Flavour, juiciness, texture and tenderness of the cooked meat were evaluated by 15 semi-trained panel members using a 8 to 1 point scale (with 8 indicating intense beef flavour, juicy and tender and 1 indicating off-flavour, dry, chewy or tough).

Shear value and pH

The texture of the cooked samples was measured using an Ottawa Texture Measuring System (OTMS), with the overall penetrating value (shear) being an average of five measurements.

pH measurements were made according to the method of (Moore *et al.*, 1980). 10 g of ground muscle was blended with 100 ml of distilled water in an electric blender for 2 min. The slurry was brought to 25°C and stirred for 30 s with a magnetic stirrer; then the pH was measured with a pH meter against a buffer of pH 6·86 (Orion Research pH meter).

Chemical analysis

The moisture, ether extract, protein and ash contents of the meat samples were determined by AOAC methods (1980). The 2,6-dichlorophenol indophenol titration method (AOAC, 1980) was used for the determination of vitamin C. Results are expressed as mg per 100 g of sample.

RESULTS AND DISCUSSION

Cooking time, cooking loss, shear value and pH

The data presented in Table 1 demonstrate that the cooking time for the meat cooked in the conventional oven was much higher than that cooked in the microwave oven. The same trend was observed for reheating time. Average cooking and reheating times were 45 and 25 min for the conventional oven and 15 and 6 min for the microwave oven, respectively. Moore *et al.* (1980) reported that cooking time was less for steaks cooked in microwave ovens than that for steaks cooked in the conventional oven.

Total cooking losses (%) were greater for the meat cooked in the microwave oven than for those cooked conventionally (Table 1). Cipra *et al.* (1970), Ruyack & Paul (1972) and Janicki & Appledorf (1974) reported that losses in weight were consistently higher for meat products processed by microwave oven as compared to other methods. Sawyer *et al.* (1982) have reported that the mean weight losses of beef reheated by microwave radiation were approximately 9% greater than losses of beef loaf reheated by conduction or in a convection oven.

Table 1. Effect of cooking procedure on the cooking time, cooking loss, shear value and pH of the meat samples

Treatment	Cooking time (min)	Cooking losses (%)	Penetration force (g)	pH value
Conventionally cooked beef	45	21·78	269	5·5
Microwave cooked beef	15	28·35	273	5·6
Conventionally reheated beef	25	9·25	263	5·5
Microwave reheated beef	6	11·50	269	5·7

Table 2. Mean sensory panel scores and standard deviation of different processing treatments on meats

Treatment and statistical analysis	Juiciness (8)	Tenderness (8)	Flavour (8)	Overall palatability (8)
Conventionally cooked beef	5·8	7·0	6·1	6·4
Microwave cooked beef	5·0	6·3	6·3	5·8
Conventionally reheated beef	6·1	6·8	6·7	6·5
Microwave reheated beef	5·9	6·1	6·5	6·1
Mean	5·7	6·55	6·4	6·2
Standard deviation	0·48	0·42	0·26	0·32
Cofficient of variation	11·8	15·6	24·8	19·6

Table 3. Chemical composition of conventionally and microwave-cooked and reheated meat samples (% dry weight basis)

Treatment	Moisture	Protein	Fat	Carbohydrate	Ash
Conventionally cooked beef	45·3 ± 0·200	19·0 ± 0·283	19·2 ± 0·10	4·8 ± 0·058	0·78 ± 0·019
Microwave cooked beef	44·6 ± 0·173	19·2 ± 0·288	18·7 ± 0·20	4·8 ± 0·057	0·8 ± 0·012
Conventionally reheated beef	45·5 ± 0.212	18·9 ± 0·230	18·5 ± 0·173	4·5 ± 0·115	0·8 ± 0·017
Microwave reheated beef	42·3 ± 0·246	18·8 ± 0·278	19·0 ± 0.100	5·0 ± 0·115	0·75 ± 0·014

The forces in grams required to penetrate the meat pieces were slightly less in conventionally cooked meat than in microwave-cooked samples. Differences were not normally large enough to be detected or to have any measurable effect on the quality of the cooked meat.

Sensory evaluation

Table 2 shows that the variation among the samples, standard deviations and coefficients of variability were quite high. Tenderness and juiciness (texture properties) scores of meat processed in either the conventional or microwave oven showed the same trend as determined subjectively by taste panels or objectively by penetrating force (Table 1). Headley & Jacobson (1960) and Ream *et al.* (1974) reported that conventionally roasted lamb or beef were juicier than those cooked in a microwave oven. Flavour scores showed only a slight difference between test samples. Microwave reheated and cooked meat had higher flavour scores than conventionally cooked meat. This may be due to the loss of volatiles during the longer times required by conventional heating as compared to the microwave method.

Chemical composition

The total moisture content of microwave-cooked and reheated samples and that of conventionally cooked and reheated meat showed only a slight difference (Table 3). Conventionally treated samples had a slightly higher moisture content compared to that of the microwave-treated meat. Results agree with Johnston & Baldwin (1980) who reported no significant difference in the moisture content of conventionally reheated meat and that of the microwave reheated meat. Since samples for reheating were taken from adjacent slices, the fat and protein contents would have been similar within each replication. Crude protein was slightly higher in microwave-cooked and reheated samples than that in conventionally cooked and reheated samples. Hoffman & Zabik (1985) stated that conventional baking reduced the cortical content of total nitrogen by 4% and total amino acid by 15%, whereas microwave baking increased the cortical contents of total amino acids by 2%. The carbohydrate fat and ash contents were similar for conventionally processed samples and microwave-processed meats.

Generally this study confirmed the results from previous studies without total agreement. It indicated that meat cooked in the microwave oven underwent greater cooking losses and was less juicy and tender than that cooked conventionally.

REFERENCES

Ang, C. Y., Chang, C. M., Fray, A. E. & Livingston, C. E. (1975). Effect of heating methods on vitamin retention in six fresh or frozen prepared food products. *J. Food Sci.*, **40**, 997.

AOAC (1980). *Official Methods of Analysis*, 13th edn. Association of Official Analytical Chemists, Washington, DC.

Bakanowski, S. M. & Zoller, J. M. (1984). End point temperature distribution in microwave and conventionally cooked pork. *Food Technol.*, **38**(2), 45.

Boles, J. A. & Parrish, F. C. (1990). Sensory and chemical characteristics of precooked microwave reheatable pork roasts. *J. Food Sci.*, **55**(2), 618.

Cipra, J. E., Bowers, J. A. & Hooper, A. S. (1970). Precooking and reheating of turkey. *J. Am. Dietet. Assoc.*, **58**(1), 38.

Headley, M. E. & Jacobson, M. (1960). Electronic and conventional cookery of lamb roasts. *J. Am. Dietet. Assoc.*, **36**, 337.

Hoffman, C. J. & Zabik, M. E. (1985). Effect of microwave cooking reheating on nutrients and food systems. A review of recent studies. *J. Am. Dietet. Assoc.*, **85**, 922.

Janicki, L. J. & Appledorf, H. (1974). Effect of broiling, grill frying and microwave cooking on moisture, some lipid components and total fatty acids of ground beef. *J. Food Sci.*, **39**(3), 715.

Johnston, M. B. & Baldwin, R. E. (1980). Influence of microwave reheating on selected quality factors of roast beef. *J. Food Sci.*, **45**(6), 1460.

Melton, S. L. (1983). Methodology for following lipid oxidation in muscle foods. *Food Technol.*, **25**(5), 105.

Moore, J. L., Harrison, L. D. & Dayton, A. D. (1980). Differences among top round steaks cooked by dry moist heat in a conventional or microwave oven. *J. Food Sci.*, **45**(3), 777.

Ohlsson, T. (1983). Fundamentals of microwave cooking. *Microwave World*, **4**(2), 4.

Paterson, B. C. & Parrish, F. C. (1988). Factors affecting the palatability and shelf life of precooked, microwave reheating beef roasts. *J. Food Sci.*, **53**(1), 31.

Quenzer, N. M. & Burns, E. E. (1981). Effect of the microwave steam and water blanching on freeze dried spinach. *J. Food Sci.*, **46**(2), 410.

Ream, E. E., Wilcox, E. B., Taylor, F. G. & Benner, J. A. (1974). Tenderness of beef roasts. *J. Am. Dietet. Assoc.*, **65**, 155.

Ruyack, D. F. & Paul, P. C. (1972). Conventional and microwave heating of beef: use of plastic wrap. *Home Econ. Res. J.*, **1**, 98.

Sawyer, C. A. (1983). *Microwave Ovens. Theory and Use in Food Service.* American Dietetic Association, Chicago.

Sawyer, C. A. D., Jen, J. J. & Huang, P. D. (1982). Cook chill food service system with conduction, convention and microwave reheat subsystems. Nutrient retention in beef loaf, potatoes and peas. *J. Food Sci.*, **47**(5), 1089–983.

Starrak, G. & Johnson, H. K. (1982). New approaches and methods for microwave cooking of meat. *Proc. Reciprocal Meat Conf.*, **35**, 86.