Journal of Food Protection, Vol. 51, No. 2, Pages 84-86 (February 1988)

A Research Note

Cook/Chill Foodservice System with a Microwave Oven: Coliforms and Aerobic Counts from Turkey Rolls and Slices[1]

PATRICIA A. OLLINGER-SNYDER and M. EILEEN MATTHEWS*

Department of Food Science, University of Wisconsin-Madison, Madison, Wisconsin 53706

(Received for publication April 8, 1987)

ABSTRACT

Turkey was sampled for total aerobic plate counts and coliform counts, before and after cooking, after chilled storage and after reheating in a microwave oven. Frozen turkey rolls were thawed for 48 h at 3°C. Rolls were then cooked (105, 135 and 165°C) to an internal temperature of 77°C. Cooked rolls were placed into a refrigerator operating at 1°C and chilled for 24 h. Rolls were removed from the refrigerator, sliced and refrigerated for ≤ 2 1/2 h to simulate holding conditions in a hospital cook/chill foodservice system. Slices were reheated for 30 or 40 s in a microwave oven. For the raw product, total aerobic plate counts and coliform counts ranged from 78,000 - 615,000/g and 1,600 - 38,000/g, respectively. No coliforms were found in turkey rolls following cooking and chilled storage and turkey slices reheated in a microwave oven. Cooking turkey rolls resulted in reduction of two to five orders of magnitude in total aerobic plate counts. For most trials of the experiment, counts were further reduced when turkey slices were reheated in a microwave oven. These low microbial counts may be attributed to cooking turkey rolls to an end point temperature of 77°C and storing chilled at 1°C before reheating the slices in a microwave oven.

Turkey has often been incriminated in outbreaks of foodborne diseases *(28)*. Reheating of menu items has been cited as a factor contributing to outbreaks *(6)*. Studies reviewed by Fung and Cunningham in 1980 *(18)* and those reported since then focus on survival of microorganisms in poultry and meat cooked in microwave ovens *(1,2,7,8,17,19,20,22,24,30-33)*. However, studies on the microbiological quality of chilled portioned meat reheated in microwave ovens in actual or simulated foodservice systems are limited *(3-5,10-15,21,23)*. None of these 11 studies reported on the microbiological quality of poultry reheated in microwave ovens in foodservice systems. The purpose of this study was to determine the cumulative effect of processing stages on coliform and aerobic counts of turkey rolls cooked at three different oven temperatures (105, 135 and 165°C), chilled and then reheated for brief periods (30 or 40 s) in a microwave oven as could occur in a hospital foodservice system.

MATERIALS AND METHODS

Experimental design and product

This study was part of a larger research project evaluating the quality of turkey rolls, cooking time, energy consumption and product yield. Frozen, uncooked, boneless turkey rolls were formulated in accordance with the United States Department of Agriculture specifications *(27)*. Upon delivery, rolls were stored in the original boxes at ≤-27°C in a room-size food freezer. Each roll weighed approximately 5 kg. Rolls were cooked at 105, 135 and 165°C, chilled (24 h), sliced, rechilled (≤2 1/2 h) and reheated (30 or 40 s) in a microwave oven.

For each of the six trials, one roll (one of two or one of four or one of six) was randomly selected for microbiological evaluation. Random samples were obtained by scraping the surface of the roll before and after cooking. The same roll was chilled and sliced. Ten slices were selected at random for rechilling (≤2 1/2 h) and then reheating in the microwave oven. Since the focus of this paper is on short reheating times, only samples reheated for ≤40 s are reported in Table 1. One of the 10 slices was randomly selected for microbiological evaluation by scraping the surface before and after reheating in the microwave oven.

Procedure

One week before each trial, turkey rolls were removed from the room-size freezer and transferred to a freezer (Victory, Model FS-2D-55, Plymouth Meeting, PA) operating at ≤-13°C in the Foodservice Administration Laboratory. Before roasting, rolls were removed from the freezer, and placed into a refrigerator (Victory, Model RS-2D-S3, Plymouth Meeting, PA) operating at 3°C for 48 h.

Two, four or six rolls were then removed from the refrigerator, weighed and casings removed. Copper constantan thermocouples

[1]*Research supported by the College of Agriculture and Life Sciences, University of Wisconsin-Madison. The turkey rolls were supplied through a contract (DAAK60-84-C-0089) with the Department of the Army, U.S. Army Natick Research and Development Center, Natick, MA. This publication represents the views of the authors and does not purport to reflect the positions of the Department of the Army or the Department of Defense.*

were inserted to measure the internal temperature of the rolls. Turkey rolls were then placed into full-size aluminum disposable steamtable pans and loaded into a forced air convection oven (Blodgett, Model EF-111, Burlington, VT.) set at 105, 135 or 165°C. Oven temperature and internal temperature of rolls were monitored by thermocouples attached to a recorder (Model 250, Leeds and Northrup, Milwaukee, WI). Rolls were cooked uncovered to an internal temperature of 77°C.

Rolls were then removed from the oven, weighed, placed in a clean full-size aluminum disposable steamtable pan and covered with aluminum foil. After chilled storage (1°C) for 24 h, rolls were weighed, netting was removed and rolls were sliced into 1-cm thick portions weighing approximately 100 g each. Ten slices were then placed on china dishes, covered with a plastic dome and refrigerated. After storage at 1°C for ≤2 1/2 h, slices were reheated in a microwave oven (Model 312-T, Hobart Corp., Troy, OH) for 30 or 40 s.

Time of microwave reheating was monitored by a stop-watch. Temperature of the estimated center of each slice of turkey was recorded 30 s before and when the temperature stopped rising after microwave reheating. Temperature was recorded using an electronic portable, probe type thermometer (Model Platinum 392 C, Wm Wahl Corp., Los Angeles, CA.).

TABLE 1. *Time and temperature relationships for turkey rolls cooked in a convection oven and turkey slices[a] reheated in a microwave oven.*

Trial	Heated in a convection oven time (min)/oven temp. (°C)	Reheated in a microwave oven time(s)/product temp. (°C)/mean temp. (°C)
1	289/105	30/48-72/63[b]
		40/63-75/69[b]
2	264/105	30/55-74/67[c]
3	288/105	30/63-79/70[d]
		40/59
4	198/135	30/57-71/65[b]
		40/63-78/72[b]
5	193/165	30/53-60/57[b]
		40/71-82/77[b]
6	162/165	30/59-69/63[b]
		40/66-72/69[e]

[a]Temperature recorded at center of slice.
[b]N=5 slices.
[c]N=2 slices.
[d]N=6 slices.
[e]N=3 slices.

Microbiology

Approximately 15-g samples were obtained by scraping random areas on the surface of turkey rolls before and after cooking and slices before and after reheating in the microwave oven. Homogenates were prepared for plating by adding 11 g of sample to 99 ml of Butterfield's buffered phosphate diluent and mixing for 3 min in a blender.

Procedures used were those outlined in the *Compendium of Methods for the Microbiological Examination of Foods (26).* Directions were modified by using surface plates instead of pour plates for determination of coliforms. Decimal dilutions of homogenates were prepared in Butterfield's phosphate buffer and surface plated in duplicate on both plate count agar (PCA) and violet red bile agar (VRBA). Plates were incubated at 35°C for 48 and 24 h, respectively. Following incubation, plates of VRBA having ≥30 to ≤150 colonies were counted used a Quebec Colony Counter; counts of <30 or >150 were considered as estimates of the bacterial population. For plate count agar, plates having ≥30 or ≤300 colonies were counted using a Quebec Colony Counter; counts of <30 or >300 were considered as estimates of the bacterial population.

To support the criteria for coliform enumeration on VRBA, random colonies were picked from VRBA and transferred to tubes of brilliant green lactose bile broth (BGB) containing fermentation tubes. Tubes were incubated at 35°C for 48 h to check for gas production.

Statistical analysis

Data from the six trials were subjected to a two-way analysis of variance (ANOVA). Standard F-tables were used to identify significance at the 5% level *(25).*

RESULTS AND DISCUSSION

Time and temperature relationships for turkey rolls cooked and for turkey slices reheated are presented in Table 1. Wide ranges in temperature were reported for turkey slices reheated in the microwave oven for the six trials of the experiment. Other investigators *(9,10,12,13)* have reported

TABLE 2. *Total aerobic plate counts obtained from the surface of turkey rolls before and after cooking and turkey slices reheated in a microwave oven[a].*

Trial	Cooking Time(min)/Oven temp. (°C)	count before cooking (log/g)	count after cooking (log/g)	count after chilled storage[b] (log/g)	Count after reheating 30s [log/g (°C)][c]	Count after reheating 40s [log/g (°C)][c]
1	289/105	5.07	1.65	3.00[d]	2.23(72)	NA[e]
2	264/105	5.79	<1[f]	2.42[d]	1.87[d](74)	NA[e]
3	288/105	5.50	2.60	1.18	2.87(79)	NA[e]
4	198/135	4.89	1.18[d]	<1[f]	<1[f](62)	NA[e]
5	193/165	5.45	3.19	1.70[d]	NA[e]	1.60[d]/(82)
6	162/165	5.43	1.30[d]	1[d]	NA[e]	2.86(68)

[a]One roll was followed for each trial and one sample was obtained after each process step.
[b]Chilled storage time was ≤ 26 1/2 h.
[c]Temperature of turkey slices after reheating.
[d]Estimated count.
[e]Not available-for each trial, slices were only reheated for one time period (30 or 40 s).
[f]Ten used instead of < 10 to calculate log. Log/g then reported as <1.

experiment. Other investigators *(9,10,12,13)* have reported similar findings.

Total aerobic plate counts from the surface of raw turkey rolls ranged from 78,000 to 615,000/g as shown in log format in Table 2. Cooking turkey rolls to an internal temperature of 77°C at 105, 135 or 165°C resulted in a reduction of two to five orders of magnitude in total aerobic plate counts. Counts ranged from 10 to 1,000/g when the product was held chilled for ≤26 1/2 h. For two of the six trials, counts increased during chilled storage. This could be attributed to contamination during sampling or laboratory error or possible growth during refrigeration.

Coliform counts from the surface of raw turkey rolls ranged from 1600 to 38,000/g. Complete elimination of coliforms was achieved by cooking turkey rolls to an internal temperature of 77°C at 105, 135 or 165°C. No statistically significant differences were observed for coliform or aerobic plate counts among trials or when the cooked product was chilled and then reheated in a microwave oven.

Menu items are frequently reheated in microwave ovens in hospital foodservice operations. Therefore, adequate reheating of precooked menu items is of special importance since hospitalized patients are at a high risk for foodborne illnesses *(16)*. Results from this study show no statistically significant differences in numbers of bacteria when turkey rolls were cooked to an end point temperature of 77°C, stored chilled at 1°C and reheated for brief periods (30 or 40 s) in a microwave oven. However, government guidelines *(29)* for reheating precooked food (≥74°C) should be followed in actual foodservice facilities because lack of control in one step of the food product flow could lead to a foodborne disease outbreak.

REFERENCES

1. Aleixo, J. A. G., B. Swamenathan, K. S. Jamesen, and D. E. Pratt. 1985. Destruction of pathogenic bacteria in turkeys roasted in microwave ovens. J. Food Sci. 50:873-880.
2. Baker, R. C., W. Poon, and D. V. Vadehra. 1983. Destruction of *Salmonella typhimurium* and *Staphylococcus aureus* in poultry products cooked in a conventional and microwave oven. Poultry Sci. 62:805-810.
3. Bobeng, B. J., and B. D. David. 1978 II. Quality assessment of beef loaves utilizing HACCP models. J. Amer. Dietet. Assoc. 73:530-535.
4. Bunch, W. L., M. E. Matthews, and E. H. Marth. 1976. Hospital chill foodservice systems: Acceptability and microbiological characteristics of beef-soy loaves when processed according to system procedures. J. Food Sci. 41:1273-1276.
5. Bunch, W. L., M. E. Matthews, and E. H. Marth. 1977. Fate of *Staphylococcus aureus* in beef-soy loaves subjected to procedures used in hospital chill foodservice systems. J. Food Sci. 42:565-566.
6. Bryan, F. L. 1978. Factors that contribute to outbreaks of foodborne disease. J. Food Prot. 41:816-827.
7. Carlin, F., W. Zimmerman, and A. Sundberg. 1982. Destruction of Trichina larvae in beef-pork loaves cooked in microwave ovens. J. Food Sci. 47:1096-1099, 1118.
8. Cornforth, D. P., C. P. Brennand, R. J. Brown, and D. Godfrey. 1982. Evaluation of various methods for roasting frozen turkeys. J. Food Sci. 47:1108-1112.
9. Cremer, M. L., and J. R.Chipley. 1980. Hospital ready-prepared type foodservice system: Time and temperature conditions, sensory and microbiological quality of scrambled eggs. J. Food Sci. 45:1422-1424.
10. Cremer, M. L., and J. R. Chipley. 1980. Time and temperature, microbiological and sensory assessment of roast beef in a hospital foodservice system. J. Food Sci. 45:1472-1477.
11. Dahl, C. A., M. E. Matthews, and E. H. Marth. 1978. Cook/chill foodservice systems: Microbiological quality of beef loaf at five process stages. J. Food Prot. 41:788-793.
12. Dahl, C. A., M. E. Matthews, and E. H. Marth. 1980. Cook/chill foodservice system with a microwave oven: Aerobic plate counts from beef loaf, potatoes and frozen green beans. J. Microwave Power 15:95-105.
13. Dahl, C. A., M. E. Matthews, and E. H. Marth. 1980. Fate of *Staphylococcus aureus* in beef loaf, potatoes and frozen and canned green beans after microwave-heating in a simulated cook/chill hospital foodservice system. J. Food Prot. 43:916-924.
14. Dahl, C. A., M. E. Matthews, and E. H. Marth. 1981. Survival of *Streptococcus faecium* in beef loaf and potatoes after microwave-heating in a simulated cook/chill foodservice system. J. Food Prot. 44:128-133.
15. Dahl, C. A., M. E. Matthews, and E. H. Marth. 1981. Cook/chill foodservice system with a microwave oven: Injured aerobic bacteria during food product flow. Europ. J. Appl. Microbiol. Biotechnol. 11:125-130.
16. Foster, E. M. 1971. The control of salmonellae in processed foods - a classification system and sampling plan. J. Assoc. Off. Anal. Chem. 54:259-266.
17. Fruin, J. T., and L. S. Guthertz. 1982. Survival of bacteria in food cooked by microwave oven, conventional oven and slow cookers. J. Food Prot. 45:695-698.
18. Fung, D. Y. C., and F. E. Cunningham. 1980. Effect of microwaves on microorganisms in foods. J. Food Prot. 41:641-650.
19. Kotula, A. W., K. D. Murrell, L. Acosta-Stein, and I. Tennent. 1982. Influence of rapid cooking methods on the survival of *Trichinella spiralis* in pork shops from experimentally infected pigs. J. Food Sci. 47:1006-1007.
20. Lindsay, R. E., W. A. Krissinger, and B. F. Fields. 1986. Microwave vs. conventional oven cooking of chicken: Relationship of internal temperature to surface contamination by *Salmonella typhimurium*. J. Amer. Dietet. Assoc. 86:373-374.
21. Nicholanco, S., and M. E. Matthews. 1978. Quality of beef stew in a hospital chill foodservice system. J. Am. Dietet. Assoc. 72:31-37.
22. Sawyer, C. A., S. D. Biglar, and S. S. Thompson. 1984. Internal end temperature and survival of bacterial on meats with and without polyvinylidene chloride wrap during microwave cooking. J. Food Sci. 49:972-974.
23. Sawyer, C. A., Y. M. Naidu, and S. Thompson. 1983. Cook/chill foodservice systems: Microbiological quality and end-point temperature of beef loaf, peas and potatoes after reheating by conduction, convention and microwave radiation. J. Food Prot. 46:1036-1043.
24. Schantz, P. M. 1981. Effect of microwave on trichina-infected pork. CDC Veterinary Public Health Notes Fourth Quarter. 74-75.
25. Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods. Iowa State University Press, Ames, IA.
26. Speck, M. L. 1976. Compendium of methods for the microbiological examination of foods. American Public Health Association, Washington, DC.
27. United States Department of Agriculture. 1987. Purchase of turkey and turkey products - Commodity A, B and C. US Government Printing Office, Washington, DC.
28. United States Department of Health and Human Services. 1986. CDC Surveillance Summaries 1986. Centers for Disease Control, Atlanta.
29. United States Department of Health, Education and Welfare. 1978. Food service sanitation manual. Public Health Serv., HEW Pub. No. (FDA) 78-2081. Food and Drug Admin., Div. of Retail Food Protection, Washington, DC.
30. Wright-Rudolph, L., H. W. Walker, and F. C. Parrish, Jr. 1986. Survival of *Clostridium perfringens* and aerobic bacteria in ground beef patties during microwave and conventional cookery. J. Food Prot. 49:203-206.
31. Zimmerman, W. J. 1983. An approach to safe microwave cooking of pork roasts containing *Trichinella spiralis*. J. Food Sci. 1715-1718, 1722.
32. Zimmerman, W. J. 1983. Evaluation of microwave cooking procedures and ovens for devitalizing trichinae in pork roasts. J. Food Sci. 48:856-860, 899.
33. Zimmerman, W. J., and P. J. Beach. 1982. Efficacy of microwave cooking for devitalizing trichinae in pork roasts and chops. J. Food Prot. 45:405-409.