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THE SURVIVAL OF Salmonella typhimurium IN WHOLE CHICKENS COOKED IN SLOW COOKER

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REPORT OF ORAL EXAMINATION

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HONORS CHAIRMAN REPRESENTATIVE:

THE SURVIVAL OF *Salmonella typhimurium* IN WHOLE CHICKENS COOKED IN A SLOW COOKER

BY

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Abstract

Fresh whole roasting chickens were inoculated with a culture containing 2.5 x 10^5 Salmonella typhimurium. Water or tomato sauce was added, and the chickens were cooked for six hours at the low temperature setting of the slow cooker. The pH of the sauce or broth was determined before and after cooking. At the end of the cooking period, samples were taken to determine whether any organisms survived the cooking process.

The slow cooker was effective in destroying the Salmonella typhimurium on the chickens. None were detected at the end of the cooking period.

Tests to determine the survival time of the organism on the chickens showed that the Salmonellae were destroyed at a lower temperature in the chickens with tomato sauce than in the chickens cooked with water. The low pH of the tomato sauce apparently aided in destruction of the organism.

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Introduction

In recent years, appliance manufacturers have developed many small appliances to meet the ever-changing needs of the American consumer. One such appliance is the slow cooker. Slow cookers are small appliances which cook food, often a main dish, at low temperatures over a period of several hours.

The slow cooker benefits the homemaker who works outside the home and wishes to serve a meal with minimal last-minute preparation. The full time homemaker may also use the slow cooker to utilize less tender, more economical cuts of meat, and to simmer soups and stews slowly to develop flavor.

A concern when cooking at low temperatures is reaching a sufficient temperature to destroy any organisms that might lead to a food-borne illness.

One food that might be prepared in a slow cooker is chicken. Poultry is frequently incriminated in outbreaks of food-borne illness. Domestic poultry are probably the largest source of Salmonellae in animals.(2,6) Salmonella typhimurium is the most frequent agent of food-borne illness in man.(4)

The effect of ingredients in the recipe on the survival of microorganisms should also be considered. Unlike most microbes, which generally show inhibited growth in an acid medium, Salmonella typhimurium may become more virulent.(7,8) This could be a cause for concern when preparing a dish that combines chicken with tomato sauce in a slow cooker.

The purpose of this research was to study the survival of Salmonella typhimurium in fresh whole roasting chickens cooked in a slow cooker in water and in tomato sauce. One criteria for this study was to simulate food preparation procedures commonly used in the home. Therefore, special procedures were kept to a minimum.

Review of the Literature

Concern about microbiological hazards arises when cooking at low temperatures is discussed. Because of this, several studies have been done to test the microbiological safety of slow cookers.

Ritter, O'Leary and Langlois studied the fate of several pathogens in foods prepared in a slow cooker.(11) Several foods, including chicken cacciatore (prepared with frying chicken pieces), were inoculated with a culture of organisms that was composed of Clostridium perfringens, Staphylococcus aureus, Salmonella cholerae-suis, and Salmonella typhimurium. The food items were prepared from recipes found in the instruction manuals accompanying the slow cookers, and cooked for the minimum recommended time. At the end of the cooking time samples were taken. A variety of selective mediae were used to identify and enumerate recovered organisms. No Staphylococcus aureus or Salmonellae were detected, and there was indication that only the spore form of Clostridium perfringens was present in the cooked food.

In research on the survival of Clostridium perfringens in rump roasts cooked in an electric oven or in a slow cooker, Sundberg and Carlin found that the slow cooker was as effective as an electric oven in reducing vegetative and spore counts of the organism.(13) Rump roasts were inoculated with a culture of Clostridium perfringens and stored at 5.6°C (42°F) for 16 hours. Samples were taken before cooking. The roasts were cooked on the low setting of the slow cooker for ten hours, in an electric oven set at 107°C (225°F) for nine hours, and in an electric oven set at 177°C (350°F) to an internal temperature of 77°C (171°F).

In another study comparing oven cooking to cooking in a slow cooker, plate counts from meat loaves and whole broiler-fryer chickens cooked in a slow cooker were lower than from those cooked in a conventional oven.(10) However, drip loss was higher, and palatability, tenderness, and general desirability were lower for the slow cooked foods.

Brackett and Marth studied the heating patterns of slow cookers.(3) Heating patterns at four locations in the cookers

were measured in starch gel, beef stew, baked beans, and meat loaf. The patterns were then compared with the growth zone of Clostridium perfringens and Staphylococcus aureus. It was found that in the slow cookers tested, none of the food was in the growth range for these organisms longer than two hours, provided that the cooker was not overloaded.

Bayne, Garibaldi, and Lineweaver studied the heat resistance of Salmonellae in chicken meat. (1) Portions of ground chicken pectoral muscle were inoculated with a known number of Salmonella typhimurium and Salmonella senftenberg. The samples were held for various time intervals at temperatures ranging from 55°C (131°F) to 75°C (167°F). After cooling, the contents of each tube were mixed with an enrichment medium, incubated, and then transferred to selective media. Salmonella typhimurium was destroyed by five minutes holding time at 60°C (140°F). The investigators concluded that the heat resistance of the Salmonellae was not appreciably altered by the chicken.

Materials and Methods

Slow Cookers

The two slow cookers used in this study were Rival model #3154. This model has a removable four quart stoneware liner (recommended cooking capacity 3½ quarts), glass lid, and a wrap around heating unit. The wrap around heating unit is reported by the manufacturer to facilitate even heat distribution by heating from the sides rather than concentrating heat at the bottom. (12) The temperature settings of the slow cookers are high and low which the manufacturer reports to be 149°C (300°F) and 94°C (200°F) respectively.

For purposes of this study two 1.7 cm diameter holes were drilled in the lid of each cooker, one 4.5 cm from the center, and the other 7.5 cm from the center. (Figure 1) The lids were modified so that thermometers fitted with rubber stoppers could be inserted in order to monitor the surface and internal temperatures of the chicken without lifting the lid of the cooker.

Culture

Stock cultures of Salmonella typhimurium were maintained on Tryptic soy (T-soy) agar slants with weekly transfer. Cultures were prepared for inoculation by transferring inoculum from a 24 hour culture in T-soy broth to a 50 ml sidearm flask of sterile T-soy broth, incuabting overnight at 37°C and adjusting to an optical density of 90 Klett units using a Klett Summerson Photoelectric Colorimeter. At this point the culture contained 1×10^8 organisms/ml. This was diluted in sterile water to a concentration of 1×10^5 organisms/ml. From this dilution 2.5 ml were transferred to 5 ml of T-soy broth for inoculation.

Chicken With Water

Fresh whole roasting chickens weighing approximately 3.5 lbs. were purchased at a local supermarket and stored in the refrigerator overnight. The neck and giblets were removed and discarded. The chickens were rinsed with tap water, patted

Figure 1: Slow cooker with thermometers positioned through openings in lid.

dry with paper towels, and weighed. The chickens for this set of ten samples ranged in weight from 1382 grams to 1596 grams with an average weight of 1498 grams. After weighing, the chickens were placed in the slow cooker. Approximately two ml of the inoculum were transferred to the cavity of the chicken and spread with a glass spreader. The remainder of the inoculum was spread over the outer surface of the chicken. One hundred and fifty ml of tap water were added, being careful not to rinse the chickens. A sample of the tap water was taken for pH determination. The lid was placed on the cooker and thermometers were positioned so that the bulb of one was inserted into the breast of the chicken, and the bulb of the other was in contact with the surface of the chicken. The cookers were then turned to the low temperature setting and the chickens were cooked for six hours.

Chicken With Tomato Sauce

The chickens were prepared and inoculated as described above. The ten chickens for this set of samples ranged in weight from 1313 grams to 1591 grams with an average weight of 1470 grams.

The tomato sauce was prepared by mixing a six oz. (170 gm) can of tomato paste with 150 ml tap water. A sample of the sauce was taken for pH determination. The tomato sauce was distributed over the surface of the chicken. Thermometers were positioned as before, and the chickens were cooked as described above.

Sampling Method

At the end of the cooking period samples were taken from the breast surface, cavity, and leg with a swab moistened with sterile T-soy broth, and plated on Salmonella Shigella (SS) agar. The samples were incubated at 37°C for 48 hours.

Samples of broth from the chicken cooked with water, and samples of tomato sauce from the surface, as well as broth samples from the chicken cooked in tomato sauce were collected to determine pH.

Survival Time

In order to determine the survival time of the Salmonella typhimurium on the chickens cooked in the slow cookers, the following tests were performed. The chickens were prepared and inoculated as described above and three were cooked with water and three with tomato sauce. One thermometer was positioned to measure the internal temperature of the chicken. The other opening in the cooker lid was closed with a rubber stopper. At intervals of 5°C the rubber stopper was removed and samples from the surface of the chicken (taken with a swab moistened in sterile T-soy broth) were taken and plated on SS agar. These samples were incubated for 48 hours at 37°C.

Results

The temperature in the slow cookers increased steadily. The time-temperature relationships in the chickens in the slow cookers are shown in Figures two and three. The United States Department of Agriculture recommends that food not be held between 15°C (60°F) and 52°C (125°F) for more than two or three hours. The temperature of the chickens was in this zone for 2½ hours.

Chicken Cooked With Water

The initial pH of the water ranged from 6.80 to 7.45 with an average pH of 7.09. The pH of the broth became lower during the cooking process to an average pH of 6.42. The temperatures in the slow cookers were sufficient to destroy the organism. No Salmonella typhimurium were detected at the end of the cooking period. (Table 1)

Chicken Cooked With Tomato Sauce

The pH of the tomato sauce increased slightly during the cooking process. The average initial pH of the sauce was 4.30. The final pH of the sauce on the surface of the chicken averaged 4.64, and that of the broth in the bottom of the cooker averaged 4.76. There was no evidence of the organism in the samples from the cooked chicken. (Table 2)

Survival Time

The organisms were destroyed more rapidly in the chicken cooked with tomato sauce than in the chicken cooked with water. There were no Salmonellae detected in the chicken cooked with tomato sauce by the time the internal temperature of the chicken had reached 49°C (120°F). The Salmonellae were destroyed in the chicken cooked in water by the time an internal temperature of 58°C (136°F) was reached.

The death point of the organism in the broth appears to be lower than that of the organism on the surface of the chicken. In both cooking media the organisms were destroyed in the broth by the time an internal temperature of 40°C (104°F) was reached in the chicken.

FIGURE 2: TIME - TEMPERATURE RELATIONSHIPS of CHICKEN COOKED in SLOW COOKER A

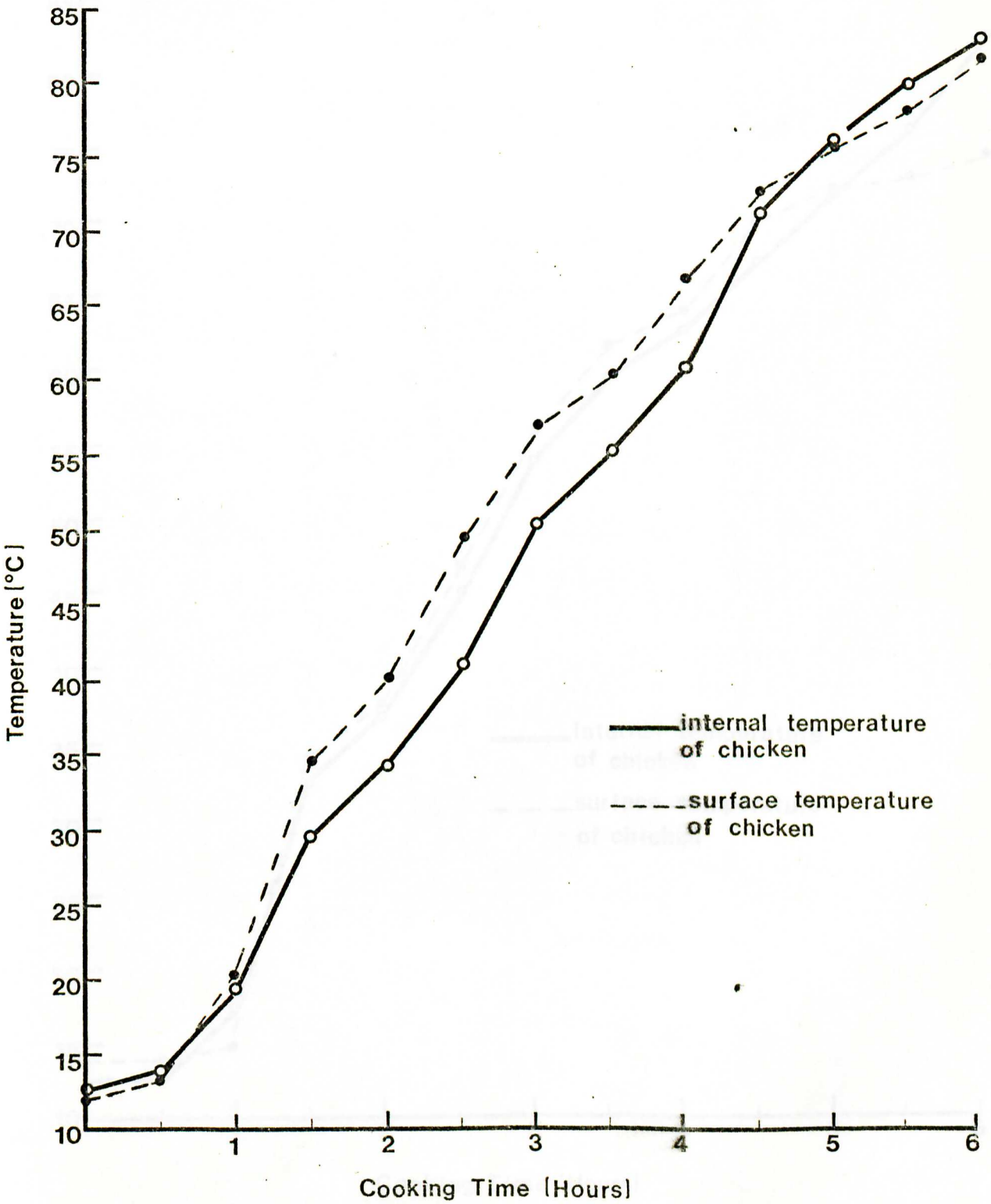

FIGURE 3: TIME-TEMPERATURE RELATIONSHIPS of CHICKEN COOKED in SLOW COOKER B

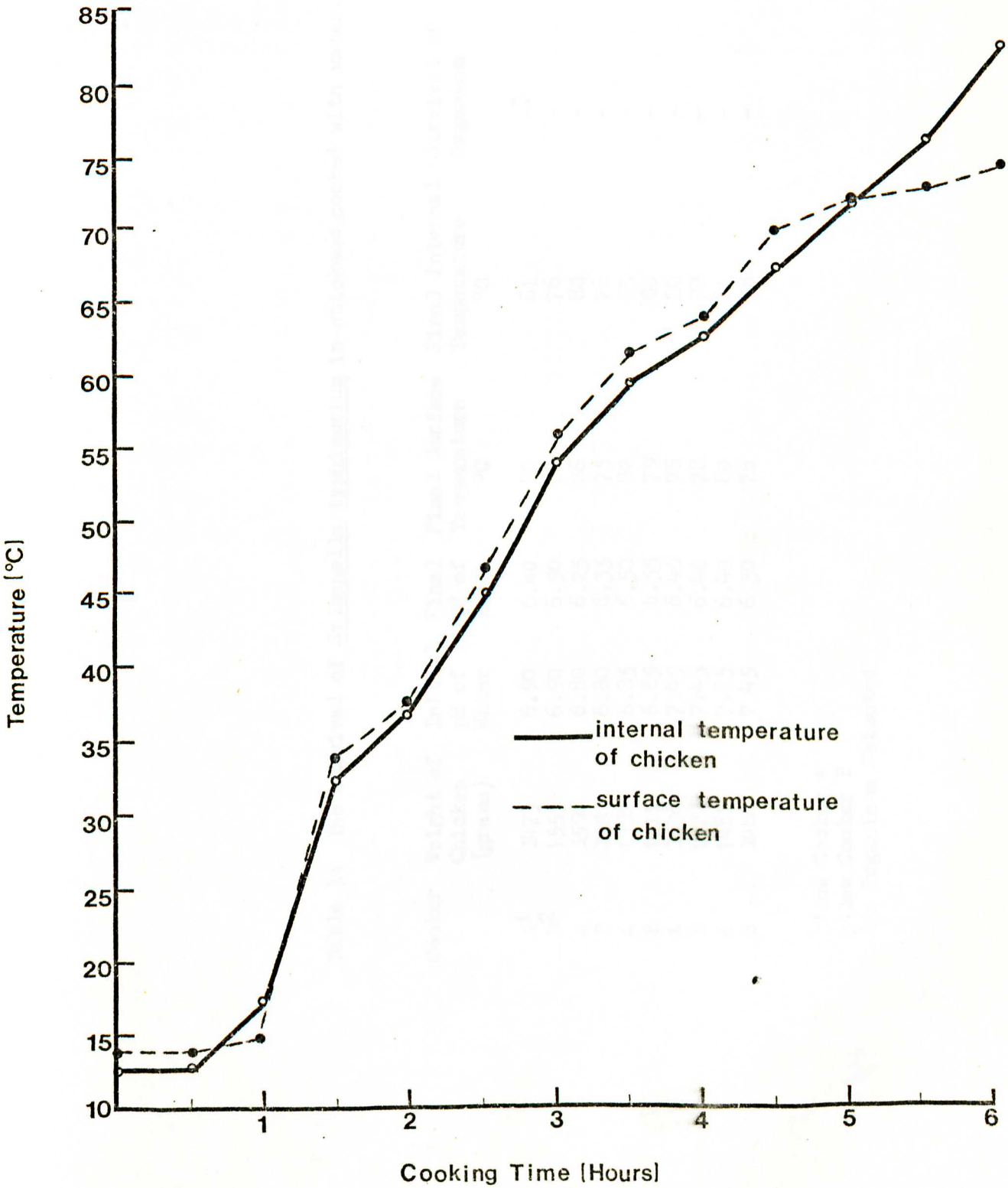

Table 1: The survival of Salmonella typhimurium in chickens cooked with water.

Cooker	Weight of Chicken (grams)	Initial pH of Water	Final pH of Broth	Final Surface Temperature °C	Final Internal Temperature °C	Survival of Organism
A[1]	1473	6.90	6.40	80	81	-[3]
B[2]	1555	6.90	6.50	77	76	-
A	1596	6.80	6.25	76	80	-
B	1593	6.80	6.35	75	76	-
A	1382	6.85	6.50	82	83	-
B	1411	6.85	6.55	79	80	-
A	1536	7.45	6.40	78	80	-
B	1472	7.45	6.40	78	78	-
A	1481	7.45	6.40	80	81	-
B	1486	7 45	6 50	78	78	-

[1]Slow Cooker A
[2]Slow Cooker B
[3]No Organisms Detected

Table 2: The survival of *Salmonella typhimurium* in chickens cooked with tomato sauce..

Cooker	Weight of Chicken (grams)	Initial pH of Sauce	Final pH of Sauce	Final pH of Broth	Final Surface Temperature °C	Final Internal Temperature °C	Survival of Organism
A[1]	1550	4.30	4.55	5.10	79	80	-[3]
B[2]	1498	4.40	4.60	4.75	78	76	-
A	1428	4.45	4.75	4.85	78	80	-
B	1406	4.20	4.45	4.70	76	75	-
A	1445	4.45	4.75	4.80	81	80	-
B	1591	4.20	4.80	4.60	78	75	-
A	1313	4.25	4.55	4.80	80	82	-
B	1531	4.25	4.85	4.65	79	80	-
A	1475	4.15	4.55	4.70	81	81	-
B	1465	4.35	4.60	4.65	79	76	-

[1]Slow Cooker A
[2]Slow Cooker B
[3]No Organisms Detected

Discussion

Many factors may affect the survival of microorganisms in foods. Among these factors are heat, moisture, the pH of the food, microbial load, and any protective properties of the food.

In this study, heat and pH were the main factors being measured, but the importance of other factors was recognized.

The United States Department of Agriculture states that: "Holding of foods for several hours in an automatic oven prior to cooking is not safe if the food is in the temperature zone of 60° to 125°F for more than 2 or 3 hours." (14) The chickens were in this zone for 2½ hours. This would allow the number of organisms to increase, however, by the time the cooking process was complete, no Salmonellae were detected. The heat of the slow cooker was sufficient to destroy the organisms present.

Moisture may have played an important role in the destruction of the organism in this study. Moist heat is more effective in destroying microorganisms than dry heat because it facilitates protein coagulation. (9) This is significant when one considers that the slow cooker is a closed system, and virtually no moisture is lost during the cooking process.

The effect of pH on the growth and virulence of Salmonellae is the topic of several studies. In one study, Salmonellae were found to grow at a pH of 4.05. (5) However, this was in a closely controlled environment, and the investigators recognized that these results may not apply to the growth of Salmonellae in food products.

Idziak and Suvanmongkol (7) studied the effect of pH on the virulence of Salmonella typhimurium. They found that under controlled conditions the organism became more virulent in an acid medium. Idziak, along with Crossley, (8) did further studies to see if this effect occurred in food items. The results of that study led the authors to state that the virulence of Salmonella typhimurium may vary from food to food. They concluded that " . . . the possibility may also exist that the ingestion of the one food could result in salmonellosis, whereas ingestion of the other, containing the same number of organisms, would not."

In the present study, low pH aided in the destruction of the organism. When the survival time of the organism in the slow cooker was studied, the organism was destroyed at a lower temperature in the chicken cooked with tomato sauce than in the chicken cooked with water. The virulence of the organism was not measured.

The number of organisms present affects the survival time. In any time interval, only a fraction of the organisms present are destroyed. (9) It was found that Salmonellae were initially present on the chickens, and the number was increased by inoculation. Although the load was increased, the slow cookers were still effective in destroying the Salmonellae present.

Protein is often thought to have protective effects on microorganisms, but as mentioned previously, earlier research showed that chicken meat had no significant effect on the survival of Salmonella typhimurium. (1) Studies reported by Bayne, Garibaldi, and Lineweaver showed that Salmonellae are generally destroyed by holding at a temperature of 60°C (140°F) for several minutes. (1)

The survival time tests performed as a part of this study showed that the organism was destroyed by the time the internal temperature of the chickens reached 58°C (138°F). The organisms in the broth were destroyed by the time the chicken had reached an internal temperature of 40°C (104°F). This may have been due to the fact that there were fewer organisms in the broth. Also, the temperature of the broth may have been higher than that of the chicken.

This study agrees with earlier studies (3, 10, 11) on the effectiveness of slow cookers in destroying non-spore forming organisms. It must be remembered, however, that the results of this study, and other studies, may only be directly applicable to the brand and model of the slow cooker used in the study.

Summary

Fresh, whole roasting chickens were inoculated with a culture containing 2.5×10^5 *Salmonella typhimurium*. Water or tomato sauce was added, and the chickens were cooked at the low temperature setting of the slow cooker for six hours. At the end of the cooking period, samples were plated on SS agar to determine whether any organisms survived the cooking process. Samples were taken to determine whether any organisms survived the cooking process. Samples were taken to determine the pH of the broth and sauce at the beginning and end of the cooking period.

Slow cooking was effective in destroying the organism -- none were detected at the end of the cooking period. Survival time tests were done, and it was found that the organism was destroyed by the time a temperature of 58°C (136°F) was reached in the chicken cooked with water, and by the time a temperature of 49°C (120°F) was reached in the chicken cooked with tomato sauce. The low pH of the tomato sauce apparently aided in destruction of the organism.

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