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THE EFFECT OF CHLORINE IN THE CHILLING WATER ON SALMONELLAE IN DRESSED CHICKEN

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In many countries poultry is considered the biggest animal reservoir of Salmonellae. In the U. S. and U. K. a wide range of Salmonellae spp. have been recorded in chickens (4, 1). In a survey of the literature *Buxton* (2) found that a total of 78 serotypes have been isolated from chickens in different countries. Almost every serotype so far found has been isolated in human food poisoning cases (10).

With the exception of bacillary white diarrhea and fowl typhoid caused by S. pullorum and S. gallinarium, Salmonellae infection in chicken has been rare in Sweden until 1957 when salmonellae-contaminated feed caused outbreaks in several flocks (7, 9). Since then various serotypes have occasionally been isolated, e. g. S. typhimurium, S. manhattan and S. montevideo.

In chicks Salmonellae very often cause an acute infection with considerable mortality whereas in older birds few if any clinical symptoms occur (6). The bacteria are usually restricted to the intestinal tract.

Avian Salmonellae may cause food poisoning by eggs and egg products or by meat. Contamination of eggs occurs mainly during

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the passage through the cloaca. Meat is infected during slaughter or subsequent handling in the processing plant. Salmonellae-infected, but symptom-free chickens are usually slaughtered with healthy birds, which therefore may be contaminated. The potential danger to public health from this is obvious.

Florin and *Nilsson* (5) found Salmonellae present in the skin of 66 per cent of chickens immediately after slaughter, while the corresponding figure in the living birds prior to slaughter was 20. The contamination of skin and meat could be markedly reduced with rigorous sanitary precautions. Dipping the slaughtered chicken in boiling water, citric acid and lactic acid gave promising results but the practical value of such procedures was nullified by the damaging effect on the appearence of the product. In precooked, frozen chicken, heat treatment has been proved valuable in destruction of Salmonellae (11). *Drewniak et al.* (3) used five different sanitizing methods under commercial conditions to determine their effect on the bacterial flora in chickens during processing. They found chlorination of the processing water to be the superior method but their investigations did not specifically concern Salmonellae. They also found that a concentration of 20 p. p. m. chlorine had a markedly better effect than 10 p. p. m. and that further increase in the chlorine concentration gave a low additional effect.

The present investigation was undertaken to study the effect of chlorine in the chilling water on Salmonellae contamination during slaughter.

MATERIAL AND METHODS

Carcasses of normal chickens with an average weight of 900 g. were chilled in running tap water in a stainless steel tank holding 40 liters. The running speed of the water was four liters/minute, i. e. an average holding time of the water of ten minutes. Sodium hypochlorite was added to the water by means of a drop aggregate before the tank inlet. A glass stirrer was used to ensure rapid and even distribution of the chlorine solution.

Free available chlorine in the water was determined iodometrically (8). Samples were taken at the inlet and outlet every ten minutes. The chlorine concentration was in all experiments kept as near 20 p. p. m. as possible.

The water temperature was 6° C in all experiments except in

Nos. 4 and 5 (Table 1) in which the initial temperature of 56° C was decreased gradually to 6° C over a 20 minutes period of time.

Healthy chickens were slaughtered in a commercial plant and the unchilled carcasses were immediately brought to the laboratory. Samples of freshly collected chicken feces were inoculated with different dilutions of an 18 hours old broth culture of S. typhimurium. The carefully mixed feces was then thoroughly rubbed into the skin by means of a cotton wrapped stick. The dorsolateral aspects of the back were inoculated since these areas are known from experience to be most easily contaminated during handling. The carcasses were then kept in room temperature for five minutes to allow the inoculated feces to dry, thus preventing the inoculum to be too easily rinsed off. Five carcasses were then simultaneously chilled in the tank. The chilling time was 60 minutes in all experiments.

The Salmonellae cultures were diluted so as to ensure a contamination of approximately 10^1, 10^2, 10^3 and 10^6 bacteria per square centimeter. The normal fecal bacteria were disregarded.

Samples for bacteriologic examination were taken before water chilling and after 18 hours subsequent storage at 4° C. Samples were collected by scraping an area of approximately ten square centimeters with a knife. Conventional bacteriologic methods were employed to determine Salmonellae. Kauffmann's tetrathionate broth was used as an enrichment medium and desoxycholate-citrate agar as culturing medium.

In two control experiments identical methods were employed but the chilling water was not chlorinated.

RESULTS AND DISCUSSION

The results are summarized in Tables 1 and 2. Table 1 shows that a chlorine concentration of 20 p. p. m. was able to reduce surface contamination of Salmonellae. With a skin contamination of up to 10^3 bacteria per square centimeter only one Salmonellae positive carcass was recorded following chlorine treatment. The treatment was not completely successful in experiment No. 7 in which a dosage of 10^6 bacteria had been administered. Such a heavy contamination is, however, not likely to occur under natural conditions. *Drewniak et al.* (3) noted that the bacterial number per square centimeter of the skin may reach 2×10^6 after commercial processing. The probability that 50 per cent of these

Table 1. Survival of Salmonellae on the surface of dressed chicken after chilling in chlorinated water (20 p. p. m. free chlorine).

Experiment No.	Number of carcasses	Chilling time in minutes	Temperature of chilling water (°C)	Estimated bacterial count per square cm. (S. typhimurium)	Number Salmonellae positive carcasses after treatment
1	5	60	6	10^1	0
2	5	60	6	10^2	0
3	5	60	6	10^3	1
4	5	60	6	10^3	0
5	5	60	56—6	10^3	0
6	5	60	56—6	10^3	0
7	5	60	6	10^6	5

bacteria would be accounted for by Salmonellae seems rather remote.

The artifical contamination used in our experiment seemed to be harder to remove than that occurring under natural conditions. Even after rinsing in water for 60 minutes the skin was markedly discolored by fecal content.

Table 2. Survival of Salmonellae on the surface of dressed chicken after chilling in ordinary tap water.

Experiment No.	Number of carcasses	Chilling times in minutes	Temperature of chilling water (°C)	Estimated bacterial count per spuare cm. (S typhimurium)	Number Salmonellae positive carcasses after treatment
8	5	60	6	10^3	5
9	5	60	6	10^3	5

All controls (Table 2) were positive for Salmonellae after 60 minutes treatment in non-chlorinated water. The effect on Salmonellae must therefore mainly be due to a bactericidal effect. It is possible, of course, that the mechanical action of the running water removed some of the bacteria but since all controls were positive this is probably of minor importance.

The chlorine utilization during the experiments was low. Chlorine concentration at the tank outlet was only 2—3 p. p. m. lower than at the inlet. Since the contact time for the water was ten minutes, more free chlorine utilization would have been ex-

pected. *Drewniak et al.* (3) found a chlorine utilization of 15 p. p. m. when the contact time was only one minute and 16,5 p. p. m. with 15 minutes contact time. They used a gaseous-type chlorinator whereas sodium hypochlorite was used in the present study. Sodium hypochlorite is relatively stable and this may account for the great differences in chlorine utilization in our experiment and in that by *Drewniak et al.* Further, the carcasses used in our study were rather clean with the exception of the inoculum.

Experiments Nos. 5 and 6 were designed to investigate the influence of water temperature on the utilization of chlorine. The initial temperature of 56° C was gradually lowered to 6° C over a 20 minutes period of time. No differences were recorded.

The treatment did not influence the acceptability of the product. No chlorine or other abnormal smell was found when the carcasses were tested after overnight storage in a cooling room. Panel judgements on chicken fried after overnight storage was as high for the chlorine treated product as for the untreated one.

No chlorine odor was noticed in the room where the experiments took place.

REFERENCES

1. *Blaxland J, D., W. J. Sojka, and A. M. Smither:* Avian Salmonellosis in England and Wales 1948—56 with Comment on its Prevention and Control. Vet. Rec. 1958, *70,* 374.
2. *Buxton, A.:* Salmonellosis in Animals. Vet. Rec. 1958, *70,* 1044.
3. *Drewniak, E. E., M. A. Howe, Jr., H. E. Goresline, and E. R. Bauch:* Studies on Sanitizing Methods for Use in Poultry Processing. U. S. Dep. of Agricult. 1954, Circular no 930.
4. *Edwards, P. R., D. W. Bruner, and A. B. Moran:* Salmonella Infections of Fowls. Cornell Vet. 1948, *38,* 247.
5. *Florin, S. O., and T. Nilsson:* The Influence of Slaughter Technique on Contamination of the Meat in Cases of Intestinal Salmonellosis of Poultry. Proc. VIIIth Nordic Veterinary Congr., Helsinki, 1959, p. 773.
6. *Lannek, N., N. O. Lindgren, and T. Nilsson:* Therapeutical Experiments with a New Nitrofuran Compound (Tiafur) in Salmonellosis of Chicks. Avian Diseases 1962, *4,* 228.
7. *Rutqvist, L., and E. Thal.:* Salmonella Isolated from Animals and Animal Products in Sweden During 1956—1957. Nord. Vet. Med. 1958, *10,* 234.
8. Standard Methods for the Examination of Water and Wastewater. 11 Ed. Amer. Public Health Ass. Inc. New York 1962, p. 83.

9. *Thal, E., L. Rutqvist, and K. A. Karlsson:* Salmonella bei Hühnern in Schweden. Proc. 2nd Symp. Int. Ass. Vet. Food Hyg., Basel, 1960, p. 250.
10. *Wilson, G. S., and A. A. Miles:* Topley and Wilson's Principles of Bacteriology and Immunity. 4th Ed. London, 1957, p. 1802.
11. *Woodburn, M., M. Bennion, and G. E. Vail:* Destruction of Salmonellae and Staphylococci in Precooked Poultry Products by Heat Treatment Before Freezing. Food Technol. 1962, *16*, no 6, p. 98.

SUMMARY

The authors have studied the effect of chlorination at 20 p. p. m. in the chilling water on surface contamination with Salmonellae in dressed chicken. The chickens were artificially contaminated with S. typhimurium. The results are summarized in Tables 1 and 2.

ZUSAMMENFASSUNG

Effekt von chloriertem Kühlwasser auf Oberflächeninfektionen mit Salmonella bei Federviehprodukten.

Die Verfasser haben den Effekt von chloriertem Kühlwasser auf Oberflächeninfektionen mit Salmonella bei geschlachteten und ausgenommenen Federviehprodukten studiert. Kücken wurden experimentellt mit Salmonella typhimurium infektiert. Ein Chlorgehalt von 20 p. p. m. freien Chlors im Wasser ergab eine effektive Abtötung der Infektion, wenn diese 1000 Bakterien per cm^2 nicht überstieg. Bei höherer Infektionsdosis war die Abtötung unvollständig.

SAMMANFATTNING

Effekten av klorerat kylvatten på ytinfektion med Salmonella hos fjäderfäprodukter.

Författarna har studerat effekten av klorerat kylvatten på ytinfektion med Salmonella hos slaktade och urtagna fjäderfäprodukter. Kycklingar infekterades experimentellt med Salmonellae typhi murium. En klorhalt av 20 p. p. m. fri klor i vattnet gav en effektiv avdödning av infektionen när denna icke översteg 1000 bakterier pr cm^2. Vid högre infektionsdos var avdödningen ofullständig.

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