MEAT AS A SOURCE OF INFECTION BY SALMONELLA

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The salmonellae belong to a group of nonlactose fermenting enteric organisms. All of the members of this genus are motile with the exception of Salmonella pullorum and S. gallinarium. The salmonellae grow best at 37.5°C. They will not grow below 10°C., and all are killed by exposure to 60°C. for 30 minutes (1,2).

Due to the antigenic structure of these organisms, over 900 serotypes have been discovered and named (3). Buxton's comprehensive review showed that the serotypes are widely dispersed in nature among the various species of animals. They have been isolated from man, all of man's domestic animals, many wild and domestic birds, fur bearing animals, reptiles, common laboratory animals: rodents, ticks, and flies (5). In 1963, 124 of these serotypes were isolated in this country from man, animals, animal feeds, human food, and miscellaneous sources (4).

Salmonellosis is one of the zoonoses as defined by the Joint WHO/FAO Expert Committee on Zoonoses. That is, it is a disease of infection that is naturally transmitted from animals to man. They make the following statements concerning the incidence in animals and man:

"Salmonellosis is most common in chickens, ducks and turkeys; it is frequent in rodents, less frequent in swine, not uncommon in cattle, sporadic in sheep, and occasional in various wild animals. Mortality is especially high among new-born birds and animals. Direct and indirect losses are difficult to estimate accurately but are undoubtedly very high". (6)

The increasing number of reported isolations and serotypes from cattle and swine is shown in table 1 and 2. As these are from diagnostic specimens they do not represent the true incidence of salmonella infection in these meat animals.

Table 1

Salmonellae Isolations in Cattle - United States

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle Isolates</th>
<th>Serotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>1963</td>
<td>586</td>
<td>25</td>
</tr>
</tbody>
</table>
Table 2
Salmonellae Isolations in Swine - United States

<table>
<thead>
<tr>
<th>Year</th>
<th>Swine Isolates</th>
<th>Serotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>41</td>
<td>5</td>
</tr>
<tr>
<td>1963</td>
<td>561</td>
<td>37</td>
</tr>
</tbody>
</table>

In 1958, there were 1178 reported animal isolates; in 1964, there were 4471 (4,7).

The WHO/FAO Zoonoses Committee further states:

"The reported incidence of salmonellosis in man and animals is increasing, partly because of a greater interest in the problem. The real incidence, however, is also increasing. In this connexion, the growing national and international distribution of human and animal foods susceptible to contamination is of great importance. The closest cooperation of the medical and veterinary professions is required before the problem of salmonellosis on both national and international scale can be solved". (6)

The incidence of salmonella infection in man is not known. The most reliable estimate available is the data on isolations made in the laboratories of the State health departments and major medical centers. Reported numbers of isolations by year are shown in table 3.

Table 3
Human Isolations of Salmonellae In the United States, Selected Years (4,8)

<table>
<thead>
<tr>
<th>Year</th>
<th>Typhoid</th>
<th>Other Salmonellae</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>3,268</td>
<td>723</td>
</tr>
<tr>
<td>1950</td>
<td>2,484</td>
<td>1,233</td>
</tr>
<tr>
<td>1955</td>
<td>1,704</td>
<td>5,447</td>
</tr>
<tr>
<td>1960</td>
<td>816</td>
<td>6,929</td>
</tr>
<tr>
<td>1963</td>
<td>706</td>
<td>18,649 *</td>
</tr>
</tbody>
</table>

* National surveillance began in 1962.

There is reason to believe that these figures do not represent even 1% of actual infections. Increased incidence has also been seen in England and Wales, Federal Republic of Germany, Sweden, and the Netherlands.

Investigations to determine the source of animal infections have pointed up the problem of contaminated animal feeds and feed ingredients. A working party of the Public Health Laboratory Service in Great Britain examined 1,279 samples of organic materials, complete feeds, factory dust and sacks. They found that 309 or 24% contained one or more salmonellae, with bone meal products the worst offenders. (9) The Department of Veterinary Microbiology of Texas A. & M. conducted a study of 200 samples
of animal by-products used in poultry feeds with a resulting 37 samples (18.5%) found to contain one or more (usually the latter) salmonellae. Twenty-eight species were isolated. Their studies further indicated that recontamination of the cooked ingredients was the source of the organism in the feed ingredients. (10) Pomeroy and Grady examined 980 samples and found that 175 (17.9%) contained salmonellae. The worst offenders in this study were meat scraps. (11) Smith, in an excellent study using 20 healthy baby pigs, fed contaminated bone meal and demonstrated the infection by feed source salmonellae and the uptake of the organisms by the mesenteric lymph nodes in seven of the pigs. Excretion in the first pig infected was noted on day 4 of the feeding. During the 50-day feeding trial, no salmonellae were isolated from the several other tissues examined and no salmonella antibody was demonstrated during the entire trial. (12)

Salmonellae have been found in healthy animals both on the farm and at time of slaughter. Galton and her coworkers in 1953, examined live hogs on 28 farms. Of the 340 well animals examined 3% were excreting salmonellae. (13) Among 189 pigs examined in holding lots of abattoirs 78% were positive. Leistner and coworkers also showed similar results in an investigation of midwest pig farms and packing plants. With a very small sampling, they found 2 of 75 pigs excreting salmonellae on the farm: however, 94% of fecal samples from pig holding lots were positive. (14) The recovery of more salmonellae from fecal specimens than from rectal swabs is expected and could account for some of this "increase". At the time of slaughter, they recovered salmonellae from 18% of pigs slaughtered after a short holding period and 59% positive in sows, boars and culls held over several days, though these groups were not similar. (14)

Galton also examined cattle on the farm and in the abattoir. One per cent were positive on the farm, and 12% were shown as salmonellae carriers immediately after slaughter. (13) These, too, are dissimilar groups as the slaughter animals were probably either beef cattle or cull dairy cows.

Mann examined the mesenteric lymph nodes of 100 pigs, 100 sheep, and 200 cattle. Three serotypes of salmonella were recovered from swine and four were recovered from cattle. (15) Williams (16) found healthy Louisiana swine carrying salmonellae at slaughter. Percentage recoveries varied from 33 to 100% in five different lots of swine from different farms.

The cycle of infection appears to be centered on the contamination of animal feed ingredients, and subsequently feed, the infection of animals, and the production of contaminated offal. The side chains on this main cycle are concerned with infected animals contaminating pens and trucks, infecting other animals, and infected animals leading to contamination of food products of animal origin. This cycle is shown in figure 1.

Infected animals apparently lead to contaminated meats. Cherry and his coworkers examined U. S. retail meat products in 1945. Two hundred and fifty retail samples of pork or beef were purchased, and 13 were found to contain salmonellae. The incidence was higher in pork than beef. They felt that the source was probably from the animals themselves (17). Felsenfeld, Young, and Yoshimura surveyed market meat, eggs and milk in 1950.
Figure I

THE SALMONELLAE CYCLE
Only one of 512 beef samples contained salmonellae, but 17.6% of the hamburger samples were positive. An interesting finding was made in connection with pork sampled. Only 14.3% of the pork meat from USDA inspected sources was contaminated with salmonellae; whereas nearly twice this percentage (26.8%) was found positive in non-inspected pork (18). Studies in Florida on fresh pork sausage obtained in retail markets revealed salmonellae contamination ranging from 8% in samples from national producers to 58% in those from local abattoirs. In addition, 12.5% of the smoked sausage samples were positive (19). Wilson and her coworkers in a recent study in 1961 surveyed the contamination of meat and poultry products in Cincinnati. Ninety-six retail stores were sampled over an 18 month period. Four percent of pork, 3% of lamb, and 1% of beef were salmonellae contaminated; whereas 17% of the poultry sampled were positive. Twelve serotypes were isolated and identified (20).

Reported salmonellae isolations from human foods in the U.S. in 1963 are listed in table 4.

Table 4

<table>
<thead>
<tr>
<th>Reported Isolations of Salmonellae from Human Food in the United States, 1963 (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry Meat Products</td>
</tr>
<tr>
<td>Red Meat Products</td>
</tr>
<tr>
<td>Whole Eggs</td>
</tr>
<tr>
<td>Frozen Eggs</td>
</tr>
<tr>
<td>Powdered Eggs</td>
</tr>
<tr>
<td>Other Egg Products</td>
</tr>
<tr>
<td>Other or Unknown</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

These reports represent research interests of various workers and results from investigations of outbreaks. The real level of contamination is unknown. During 1963, 279 Salmonellae isolations were made from animal feeds and ingredients. (4)

The source of sausage contamination was investigated in Florida abattoirs by Galton and coworkers by taking swabs of the environment and carcasses. Nearly half of the surface swabs of the dehairing machine yielded positive cultures. Sides of carcasses just off of the dehairing machine were also positive at similar level of 46 per cent. Much of this contamination persisted through handling to the chill room where 132 carcasses were swabbed and 27% still had salmonellae on the surface. These carcasses had been washed and singed with a resulting drop in salmonellae recoveries; however, during the evisceration process, and in spite of a subsequent washing of the carcass recovery rates returned to the high level found in the cooler.

Environmental swabs were taken of the tables and containers in the evisceration area and 17 of 23 were positive. Culturing of swabs taken in the cutting and sausage rooms resulted in a surprising 55% of over 800 cultures being found positive. All of these figures were composites of samplings in four Florida plants. (13)
This study was repeated in 1960 and 1961 in a small plant near Atlanta, Georgia that was engaged in the slaughter of sows for sausage manufacturing. In this investigation, the dehairing machine was again found a source of carcass contamination. In an effort to control this a 165°F. wash was used following evisceration. This reduced the level of contamination from 95% to 62%. A similar wash before and after evisceration further reduced it to 35%. An additional interesting finding of this study was the demonstration of aerosol spread of salmonellae within this small plant (21).

In a major investigation, 17 laboratories in England examined 4496 floor drain swabs from 32 abattoirs with a resulting 21% positive for one or more salmonellae. These give a crude measure of the salmonellae exposure level of a plant. Two percent of 11,357 tissue specimens collected in abattoirs were positive. Drain swabs placed in butcher shops were positive 6.5% of the time. Retail meat products were positive at the low level of 1% of 4127 samples. However, investigation and study of the different serotypes and phage types of S. typhi-murium occurring in a given abattoir and in human cases in the area surrounding it gave convincing evidence that meat or meat products were the source of 6 food poisoning outbreaks, with 281 persons infected (22).

From the previous data, it is apparent that an animal cycle of salmonella infection does exist in this and other developed countries of the world. Meat produced from these animals could serve as a source of human salmonellosis. It could be infected or contaminated in the following ways:

1. Antemortem during a septicemic state. It is unlikely that emergency slaughter of a clinical case of animal salmonellosis often occurs in this country.

2. Contamination of the meat during slaughtering and wholesale processing. This is our major problem.

3. During manufacture into various meat containing food products that are destined for wide distribution.

4. During storage.

5. During preparation and serving in a commercial eating establishment or the home.

The major problem in this country is the asymptomatic animal bearing salmonellae in its intestinal tract contaminating the areas of slaughter and processing. In unusual situations, rats and flies have been shown to act as a vehicle of contamination for meat and meat products in foreign abattoirs; however, in studying the serotypes these vermin and insects carried, their source of infection was the offal from infected animals slaughtered in the plant. (23, 24). The investigation of several recent outbreaks in England has incriminated sewage contaminated cooling water as a source of salmonellae in canned meats imported from foreign plants. (25,26,27). The recent Scottish typhoid outbreak was one of these. In 1964, two outbreaks of salmonellosis in the area of Denver, Colorado, were traced to a delicatessen that catered to luncheons and banquets. Though it could
not be proved, in retrospect, the apparent source of this outbreak was the
head cook who became infected while on a trip abroad. He contaminated the
meat and infected other employees working in the food preparation area. (28).
This was an example of a human carrier causing illness with a meat vehicle.

A processed product being contaminated was shown when beef jerky
was found to be the source of 11 illnesses due to *S. bredeney* in California.
The mode of contamination was not known in this instance. (29)

A large outbreak with 114 known cases of *S. javiana* infection
occurred in Alabama in the fall of 1964. Fifteen percent of the students
and teachers eating in a school cafeteria suffered diarrhea, cramps, and
weakness 9 - 12 hours following the noon luncheon of roast beef. This was
USDA inspected frozen boned beef that was thawed, cooked, improperly re-
frigerated, reheated, and served from a steam table. *S. javiana* was isolated
from the meat. No other source of the organism was found. (30)

One of the larger documented outbreaks in recent years occurred in
Sweden in 1956-57. The final case count was 494 persons with 2 deaths. There
was no selected age, sex, occupation, or social grouping in these cases dis-
tributed over a wide area. The careful epidemiological investigation that
followed demonstrated the same phage types of *S. typhi-murium* in New Zealand
imported boned veal and the persons eating it in a special Christmas dish
popular in Sweden. These same phage types were found to be common in
*S. typhi-murium* human outbreaks in New Zealand in a calf isolate sent to a
Swedish laboratory by a New Zealand Veterinary diagnostic laboratory (31).
These few outbreaks cited are examples of different meat vehicles of
salmonellosis.

The control of these and other salmonella incidents depends on
the interruption of the cycles already discussed.

1. The first line of defense is the prevention of the
recontamination of animal origin ingredients in
animal feeds. We should send animals to slaughter
free of salmonellae and other pathogens.

2. Abattoir hygiene must be the best possible with improvement
of facilities in some plants if necessary. This could
include pen sanitation.

3. Food handlers and processors should be educated as to
their place in the field of control. This could well
include housewives.

4. Flies and rodents must be excluded from food plants.

5. Only potable water should be used in manufacturing processes,
including can cooling.

6. Food of animal origin should be kept hot or cold, not in
the incubation range of this and other foodborne organisms.

7. Epidemiological studies should continue to demonstrate new
problems, and show methods to control them.
The medical profession, the veterinary profession, the food industry, the animal feed industry, and concerned research groups can well work together to overcome the increasing incidence of human salmonellosis in this country and those countries receiving our animal origin food products.

BIBLIOGRAPHY


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MR. SULZBACKER: Thank you, Paul. We appreciate this. The Executive Committee wisely thought that by this time everyone would be getting tired and so they suggested that at about this time of the morning I ask Ellis Pierce if he would not take this back and see if he couldn't wake us up in some way.

ELLIS PIERCE: Thank you very much, Bill, not only for the opportunity for a break, but also for the three very stimulating presentations which you brought to us this morning. One brief announcement. Would Dr. Briskey please see me during the break. The refreshments have been set up out in the foyer, and the Conference will reconvene at 20 minutes after the hour.

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Ladies and Gentlemen, we will continue with this mornings very interesting program by awarding the door prize. Herbert Hall is the lucky individual.

Our good secretary, Dr. Bill Sherman, informed me that he had a couple of announcements that he would like to make, so Bill, please take over.

DR. W. C. SHERMAN: Thank you Ellis...just a couple of quick announcements. First of all regarding publicity, press releases and trade press...we asked again this year to have copies sent to the Meat Board office in advance so that we could have our people prepare them.

Quite a few of them have come in but if there are any more of you speakers who have abstracts, please turn them in. Is Sandra Brookover in the room....I don't see her. The Press Room is right off the room where we had coffee, right behind the Director's Conference
Room. Miss Brookover is a brunette from Kansas and she works with Dick Smith in the Meat News and Information Department. We also asked for manuscripts in advance this year to help out in preparing the proceedings. We received about ten of them out of sixty - but at least that helps. Please do turn in manuscripts. We can transcribe the presentations and have the speaker edit it which is difficult, but we lose all of the tabular material. We never have as good a paper in our proceedings if we don't have the manuscript. Now, there was one other thing. Oh yes, I must not forget the main reason I am here and that is to make a presentation to our Chairman this year of a gavel. Ellis, will you please step forward. This is from the membership of the American Meat Science Association for your outstanding performance as chairman.

(Applause)

DR. ELLIS PIERCE: Thank you Bill and members of the Association. This is a pretty instrument, but I don't know whether I dare use it or not because I am already running about 15 minutes behind schedule. However, at the risk of getting a little further behind, I would like to draw your attention to this information sheet that is available on the Registration Desk. It concerns employment possibilities, and the Information Committee suggested that I bring it to your attention. Especially those of you who may be interested in employment. We would like to get this information from you so that it will be available for use by prospective employers as well as prospective employees. A supply of these sheets is available on the Registration Desk, out in the general lobby.

We are now ready to get back to our program. Bill Sulzbacher, will you please come forward and accept my apologies for encroaching on your time?

MR. SULZBACHER: The members of our Microbiological Committee, when asked about this program, all suggested that we include in the discussion this morning a sort of side issue to this main problem. In the last several years workers in the area of food microbiology have become very much interested in the studies that have appeared on the toxins produced by certain molds of the aspergillus group. These, because they are found in molds of the Aspergillus flavus group, are sometimes called afla toxins, but more generally we are using the term mycotoxins, in other words, toxins from molds. We began looking around for somebody who could present this in a knowledgeable and concise manner and I thought about Al Campbell. Al is with the Food and Drug Administration in Washington. The Food and Drug Administration is very much concerned with this subject, and with what dangers these mycotoxins might present to our health and to our food supply. I asked his Chief about inviting him to this conference. He said yes, he would be very glad to have him come and speak to us, but he wanted to emphasize that the Food and Drug Administration might also be concerned in many legal aspects of mycotoxins and we should understand that Dr. Campbell is speaking to us today just as a fellow scientist and he is not here to tell us what legal position the Food and Drug Administration may or may not take in the future. I said that is just exactly what we wanted him for -- to scientifically review the subject. So, I am pleased to introduce Dr. Al Campbell of the Food and Drug Administration.