Bacteriological Survey of Market Poultry Livers

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Literature reviews and textbooks list over 30 disease agents as being “common to man and poultry.” Among these are such bacterial agents as Brucella sp., Clostridium sp., Corynebacterium diphtheriae, Erysipelothrix insidiosa, Listeria monocytogenes, Mycobacterium avium, Paracolobacterium sp., Pasteurella sp., Salmonella sp., and Staphylococcus aureus (Galton and Arnstein, 1959; Hull, 1964; Ingalls, 1950; Brandy, 1948, 1951; and Felsenfeld, 1951). Poultry are implicated to varying degrees as a source of infection in man by these organisms. Since a review of the literature reveals no report of a random sampling of market fowl, any estimate as to the incidence or prevalence of these agents in the population of market poultry must be based upon data derived from examination of diseased poultry submitted to diagnostic laboratories. Basing any estimate on such data would obviously be extremely prejudiced since it would be influenced by the ease of diagnosis of specific diseases, the specific interests of the various diagnosticians, the facilities available in the various diagnostic laboratories, and other factors.

There are numerous reports of studies of the incidence and kinds of microorganisms associated with commercially dressed poultry (Walker and Ayres, 1956, 1959; Thatcher and Loit, 1961; Smith, 1959; Salzer et al., 1964; Ravenholt, 1961), but none have reported studies with suitably randomized sampling procedures or techniques that would differentiate between organisms that were indigenous to the poultry tissues and those that were merely contaminants. Further, the literature provides no evidence as to what extent present inspection procedures are successful in detecting carcasses infected with these pathogenic agents and removing them from food channels.

Since facilities, personnel, and other limitations would preclude an exhaustive survey of tissues, it would seem logical to examine the liver (as key evidence of systemic distribution of an organism, and also because of its importance as an edible organ) and intestinal tract (because of the well-known role of fecal contamination in disseminating such organisms as the salmonellae and paracolons). This paper reports the results of a random sampling of livers of three market classes of poultry being commercially slaughtered. Concurrent sampling of intestines are reported in two other surveys (Sadler et al., 1961, 1965).

Materials and Methods

Samplings were made over a period of 4 years in 8 large federally inspected chicken and turkey processing plants, drawing from the poultry populations of northern and central California and western Nevada. One of the 8 plants was randomly chosen for each of the 67 sampling days. In an effort to randomize the sampling of livers, every one-hundredth liver was taken immediately after it had passed the official inspection point. In some instances, livers were deliberately taken out of sequence be-
cause they had been condemned by the government inspector. Also taken in these cases was the tenth normal liver following this condemned one. Each liver was placed in a half-pint ice cream carton which was then sealed and covered with ice in an aluminum canister for transport to the laboratory at Davis. When intestines were concurrently sampled, a section of the intestines and cecum was also taken, or a cloacal swab was taken by methods described elsewhere (Sadler et al., 1961). Records were kept of the disposition of the individual liver as well as the carcass from which it originated.

Samples were returned to the laboratory, usually within 4 hours, and cultured immediately. In a few instances the samples were held overnight in a refrigerator. The largest surface of the liver was seared with a hot iron spatula, a stiff inoculating loop was inserted through the seared surface, and pieces of tissue of 2–3 cubic mm. were removed for culture. The media and routine used for bacterial isolations for all suspected tissues included inoculation of blood agar plates, tryptose broth (Difco) enriched with 5% horse serum, and thioglycollate medium (BBL). The direct blood agar plate inoculation gave an indication of relative numbers of aerobic organisms present in the tissue cultured. If a large number of aerobes had been present, they would have presumably been readily detected by this method. If only a small number of organisms were present, however, enrichment through broth media and subsequent plating to blood agar were necessary to obtain a large enough population for detection by bacteriological means. The thioglycollate medium, in addition to its enrichment quality, supported growth of micro-aerophilic and anaerobic organisms. Thus, the combination of media increased the chance of isolating a greater number and range of organisms with greater frequency. Isolates were identified by routine procedures (Breed et al., 1957; Schaub et al., 1958).

Size of sample was limited by the ability of the laboratory to handle the workload. An average of 37 samples were taken on each of the 67 sampling days, resulting in a total of 2,513 livers sampled. These were taken from 871 turkeys, 718 chicken hens (old layers), and 924 chicken fryers.

RESULTS AND DISCUSSION

The data from the three market classes sampled are presented in Tables 1, 2, and 3. Three basic categories of livers were taken from each of the market classes: normal livers from carcasses passed as wholesome; livers condemned as unwholesome from carcasses passed as wholesome; and livers from carcasses condemned as unwholesome. Since these last livers might or might not have been condemned on their own merits if they had not come from a condemned carcass, it is difficult to assign a wholesomeness category to them per se. Causes of carcass condemnation are listed under four categories: septicemia-toxemia, inflammatory process, leucosis, and other causes (bruising, tumors, overscald, etc.). Only one condemned liver was examined from a passed carcass in the fryers, and only two such livers in the chicken hens, whereas the numbers of condemned and passed livers examined from passed turkey carcasses were almost equal. Two factors would account for this. First, the fact that fewer livers in chicken fryers and chicken hens are condemned by themselves without condemnation of the rest of the viscera (thus confusing the point of condemnation of livers per se), and secondly, the fact that the inspector mutilated fryer and hen livers to such an extent when he removed them for condemnation that it was usually impractical to attempt to culture from uncontaminated tissue. Turkey
### Table 1.—Percentage of turkey livers of indicated origin yielding indicated organism

<table>
<thead>
<tr>
<th>Total sampled</th>
<th>Passed carcass</th>
<th>Condemned carcass</th>
<th>Sept. tox.</th>
<th>Infl. proc.</th>
<th>Leucosis</th>
<th>Unknown or other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passed liver</td>
<td>Condemned liver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achromobacter sp.</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacillus sp.</td>
<td>3.6</td>
<td>2.1</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Coliform group</td>
<td>5.8</td>
<td>6.5</td>
<td>17.5</td>
<td>12.8</td>
<td>16.7</td>
<td>25.0</td>
</tr>
<tr>
<td>Diphtheroids</td>
<td>2.4</td>
<td>4.1</td>
<td>3.5</td>
<td>2.1</td>
<td>16.7</td>
<td>0</td>
</tr>
<tr>
<td>Lactobacillus sp.</td>
<td>4.3</td>
<td>1.2</td>
<td>10.5</td>
<td>6.4</td>
<td>16.7</td>
<td>0</td>
</tr>
<tr>
<td>Paracolobactrum sp. (not arizonae)</td>
<td>0.2</td>
<td>0.3</td>
<td>1.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pasteurella multocida</td>
<td>0.2</td>
<td>0.3</td>
<td>1.8</td>
<td>6.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pasteurella hemolytica</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Proteus sp.</td>
<td>0.5</td>
<td>0.5</td>
<td>1.8</td>
<td>2.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pseudomonas sp.</td>
<td>0.2</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus aureus (coagulase-positive)</td>
<td>0.7</td>
<td>1.5</td>
<td>5.3</td>
<td>4.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus aureus (coagulase-negative)</td>
<td>5.3</td>
<td>5.9</td>
<td>5.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Streptococcus sp. (beta hemolytic)</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Streptococcus sp. (alpha and gamma hemolytic)</td>
<td>5.3</td>
<td>11.2</td>
<td>3.5</td>
<td>12.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Streptococcus sp. (anaerobic)</td>
<td>3.4</td>
<td>2.1</td>
<td>3.5</td>
<td>2.1</td>
<td>0</td>
<td>25.0</td>
</tr>
</tbody>
</table>

Livers, in contrast, being larger and of more economic value, are examined more carefully and removed without such severe mutilation.

Table 4 presents the percentage of livers in each market category that yielded each of the listed organisms, and the percentage of sampling days on which each organism was isolated from at least 1 liver. The number of days on which these organisms were isolated is thought to be of more significance than the specific number of

### Table 2.—Percentage of chicken fryer livers of indicated origin yielding indicated organism

<table>
<thead>
<tr>
<th>Total sampled</th>
<th>Passed carcass</th>
<th>Condemned carcass</th>
<th>Sept. tox.</th>
<th>Infl. proc.</th>
<th>Leucosis</th>
<th>Unknown or other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passed liver</td>
<td>Condemned liver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achromobacter sp.</td>
<td>3.1</td>
<td>0</td>
<td>3.7</td>
<td>1.2</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>Bacillus sp.</td>
<td>2.8</td>
<td>0</td>
<td>0</td>
<td>1.2</td>
<td>8.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Clostridium perfringens (welchii)</td>
<td>0</td>
<td>0</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clostridium sp. (not perfringens)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Coliform group</td>
<td>21.4</td>
<td>0</td>
<td>40.0</td>
<td>34.8</td>
<td>29.2</td>
<td>23.8</td>
</tr>
<tr>
<td>Diphtheroids</td>
<td>1.4</td>
<td>0</td>
<td>1.5</td>
<td>2.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lactobacillus sp.</td>
<td>5.5</td>
<td>0</td>
<td>1.5</td>
<td>2.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Paracolobactrum sp. (not arizonae)</td>
<td>0.3</td>
<td>0</td>
<td>0.7</td>
<td>3.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Proteus sp.</td>
<td>0.5</td>
<td>0</td>
<td>0.7</td>
<td>4.3</td>
<td>0</td>
<td>4.8</td>
</tr>
<tr>
<td>Pseudomonas sp.</td>
<td>0</td>
<td>0</td>
<td>3.7</td>
<td>3.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus aureus (coagulase-positive)</td>
<td>1.2</td>
<td>0</td>
<td>1.5</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus aureus (coagulase-negative)</td>
<td>10.2</td>
<td>0</td>
<td>7.4</td>
<td>3.0</td>
<td>0</td>
<td>9.5</td>
</tr>
<tr>
<td>Streptococcus sp. (beta hemolytic)</td>
<td>2.2</td>
<td>0</td>
<td>0</td>
<td>0.6</td>
<td>4.2</td>
<td>0</td>
</tr>
<tr>
<td>Streptococcus sp. (alpha and gamma hemolytic)</td>
<td>18.7</td>
<td>0</td>
<td>14.0</td>
<td>12.2</td>
<td>6.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Streptococcus sp. (anaerobic)</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### Table 3.—Percentage of chicken hen livers of indicated origin yielding indicated organism

<table>
<thead>
<tr>
<th>Percent positive isolation</th>
<th>Passed carcass</th>
<th>Condemned carcass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passed liver</td>
<td>Condemned liver</td>
</tr>
<tr>
<td>Total sampled</td>
<td>405</td>
<td>2</td>
</tr>
<tr>
<td>Percent yielding no organism</td>
<td>62.2</td>
<td>100</td>
</tr>
<tr>
<td><em>Achromobacter</em> sp.</td>
<td>5.9</td>
<td>0</td>
</tr>
<tr>
<td><em>Bacillus</em> sp.</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> (welchii)</td>
<td>9.6</td>
<td>0</td>
</tr>
<tr>
<td>Clostridium sp.</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Lactobacillus</em> sp.</td>
<td>4.9</td>
<td>0</td>
</tr>
<tr>
<td><em>Paracolobactrum</em> sp. (not arizonae)</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Pasteurella</em> hemolytica</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Proteus</em> sp.</td>
<td>2.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Pseudomonas</em> sp.</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (coagulase-positive)</td>
<td>3.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (coagulase-negative)</td>
<td>8.1</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (alpha and gamma hemolytic)</td>
<td>13.6</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (anaerobic)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Listeria</em> monocytogenes</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Lysteria</em> monocytogenes</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Paracolobactrum</em> arizonae</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td><em>Pasteurella</em> malocida</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Pasteurella</em> hemolytica</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td><em>Proteus</em> sp.</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td><em>Pseudomonas</em> sp.</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Salmonella</em> sp.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (coagulase-positive)</td>
<td>5.2</td>
<td>0</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (Coagulase-negative)</td>
<td>13.0</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (beta hemolytic)</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (alpha and gamma hemolytic)</td>
<td>2.9</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (anaerobic)</td>
<td>2.9</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 4.—Percentage of livers yielding organism and percentage of sampling days on which isolations were made

<table>
<thead>
<tr>
<th>Percent positive isolations</th>
<th>Turkeys</th>
<th>Chicken hens</th>
<th>Chicken fryers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Livers</td>
<td>Days</td>
<td>Livers</td>
</tr>
<tr>
<td>Total sampled</td>
<td>871</td>
<td>23</td>
<td>718</td>
</tr>
<tr>
<td>Percent negative</td>
<td>62.6</td>
<td>0</td>
<td>55.3</td>
</tr>
<tr>
<td>Percent positive</td>
<td>37.4</td>
<td>100</td>
<td>44.7</td>
</tr>
<tr>
<td><em>Achromobacter</em> sp.</td>
<td>0.1</td>
<td>8.7</td>
<td>6.5</td>
</tr>
<tr>
<td><em>Bacillus</em> sp.</td>
<td>3.0</td>
<td>47.8</td>
<td>0.7</td>
</tr>
<tr>
<td><em>Brucella</em> sp.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> (welchii)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><em>Clostridium</em> sp. (not perfringens)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><em>Coliform</em> group</td>
<td>7.3</td>
<td>73.9</td>
<td>1.8</td>
</tr>
<tr>
<td><em>Diptheroids</em></td>
<td>3.2</td>
<td>39.1</td>
<td>0</td>
</tr>
<tr>
<td><em>Erysiphalae</em> insidiosa (rhusiopathiae)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><em>Lactobacillus</em> sp.</td>
<td>3.7</td>
<td>39.1</td>
<td>5.6</td>
</tr>
<tr>
<td><em>Listeria</em> monocyrogenes</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Paracolobactrum</em> arizonae</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Paracolobactrum</em> sp. (not arizonae)</td>
<td>0.3</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td><em>Pasteurella</em> malocida</td>
<td>0.7</td>
<td>8.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Pasteurella</em> hemolytica</td>
<td>0.1</td>
<td>4.3</td>
<td>1.1</td>
</tr>
<tr>
<td><em>Proteus</em> sp.</td>
<td>0.5</td>
<td>13.0</td>
<td>2.2</td>
</tr>
<tr>
<td><em>Pseudomonas</em> sp.</td>
<td>0.2</td>
<td>8.7</td>
<td>0.6</td>
</tr>
<tr>
<td><em>Salmonella</em> sp.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (coagulase-positive)</td>
<td>1.5</td>
<td>34.8</td>
<td></td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (Coagulase-negative)</td>
<td>5.2</td>
<td>60.9</td>
<td></td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (beta hemolytic)</td>
<td>0.5</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (alpha and gamma hemolytic)</td>
<td>7.8</td>
<td>73.9</td>
<td></td>
</tr>
<tr>
<td><em>Streptococcus</em> sp. (anaerobic)</td>
<td>2.9</td>
<td>39.1</td>
<td></td>
</tr>
</tbody>
</table>
BACTERIOLOGICAL SURVEY OF LIVERS

livers from which they were isolated—for several reasons: First, it is felt that one deep stab culture from a liver might fail to reveal organisms present in small numbers, and, in instances of multiple infections, overgrowth would mask the presence of species present only in small numbers. Second, organisms present in livers on a given day offer opportunity for contamination of other livers and tissues being processed at the same time even though these livers do not themselves contain the organisms. Total numbers of sampling days are roughly equal between the three market groups of birds sampled. No striking difference is evident in types of organisms isolated from the three different market groups. It is apparent that the most predominant organisms are, in descending order, the coliform group, alpha and gamma hemolytic streptococci, coagulase-negative staphylococci, Lactobacillus sp., Achromobacter sp., Bacillus sp., and Proteus sp.

It is quite apparent from Table 4 that the livers sampled did not contain Brucella sp., Clostridium perfringens, Erysipelothrix insidiosa, Listeria monocytogenes, Paracolobactrum arizonae, or Salmonella sp. In view of the randomness of the sampling, the large populations represented, and the laboratory techniques employed, it is believed that these findings indicate that these organisms are not present in the tissues of market meat fowl except in rare instances. A total of 40 coagulase-positive and 178 coagulase-negative staphylococci were isolated, and the characteristics of 157 of these isolates are reported elsewhere (Genigeorgis and Sadler, 1965).

SUMMARY

A randomized sampling was made of livers of market poultry being processed in one of 8 processing plants on 67 days over a period of 4 years. Bacteriological examination of 2,513 chicken or turkey livers revealed the presence of coliforms, streptococci, staphylococci (including coagulase-positive strains), Lactobacillus sp., Achromobacter sp., Bacillus sp., Proteus sp., diptheroids, Pseudomonas sp., Pasteurella sp., Clostridium sp., and paracolons. No evidence was found that the large populations of market poultry sampled harbored in their tissues such human pathogens as Brucella sp., Erysipelothrix insidiosa, Listeria monocytogenes, Paracolobactrum arizonae, or Salmonella sp.

REFERENCES

Salzer, R. H., A. A. Kraft and J. C. Ayres. 1964. Bacteria associated with giblets of commercially

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For many years the results of our experimental work with Escherichia coli seemed to lack the consistency that we desired. At times the same inoculum given to different groups of birds resulted in varying numbers of birds with pericarditis. Healthy uninoculated birds were raised in many batteries in an isolated building. When needed, birds were placed in the experimental cages from one or more batteries. Frequently birds from several battery sources remained in small experimental cages for from 1–7 days before being exposed to E. coli.

Davis and Reed (1958) infected two groups of mice with Trichinella spiralis. The individuals in one group were isolated in individual cages while the others were allowed to fight in small groups for 4 hrs. daily. Isolated mice had fewer mature trichina than those which were allowed to fight.

Newcomer (1958) found that chickens which were stressed by shaking or restraint had an increase in heterophiles and a decrease in lymphocytes. This also occurred following injections of ACTH and other stress. Similar results were found by Grundboeck (1964) following shaking, ACTH injection and 12 hours after infection with Salmonella gallinarum. Shaking did not influence the course of Salmonella gallinarum infection.

EXPERIMENTAL PROCEDURE

The male White Leghorn chickens used in these experiments were obtained from the Veterinary Science Department’s closed breeding flocks and were free from respiratory diseases. When 4-weeks of age 6 birds used in experiments 1, 2 and 3 were placed in each of eight 2 × 2 × 2 feet modified Horsfall-Bauer units which had half silvered plastic over the observation windows. With the room darkened the birds could be observed without their being disturbed. At 56 days of age the 6 birds in each of 2 cages were designated as controls and were not moved but were handled each day for the next 2 weeks. In the remaining microflora of chlortetracycline-treated and non-treated poultry with special reference to public health aspects. Appl. Microbiol. 9: 39–45.
