bismuth ammonium citrate and ferric ammonium citrate in place of bismuth citrate and ferrous sulfate, respectively, has been given.

The use of both enrichment broths (Selenite F and (TT) is necessary if the maximum number of recoveries of enteric pathogens is to be obtained.

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Incidence and Kinds of Microorganisms Associated with Commercially Dressed Poultry[1,2]

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In recent years there has been a rapid expansion in the commercial processing of eviscerated, ready-to-cook poultry. As with any food product, the sanitation under which these birds are produced is of major concern. Products that are excessively contaminated are undesirable from several points of view, namely, public health aspects, storage quality, and general esthetic principles.

The processing line seems to be an important avenue for disseminating microorganisms. Ayres *et al.* (1950) and Drewniak *et al.* (1954) have suggested that the flora that develop on the bird derive largely from the feet, feathers, feces, and skin. The number of organisms that occur on the bird's skin surface would indicate the extent of contamination from these sources.

Little published information is available as to the usual loads of organisms encountered in commercial processing plants. Drewniak *et al.* (1954) selected a plant which appeared to follow the sanitation practices most commonly used in commercial plants to determine the effect of various sanitizing procedures. They reported a count of 380,000 organisms per cm^2 after a bird had gone through the rough picker and a count of 17,000 per cm^2 as it came from the eviscerating line. These workers concluded that dressing, eviscerating, and cutting operations as practiced in most plants can be expected to lower the bacterial count.

Gunderson *et al.* (1954) made a bacteriological survey of typical, approved commercial poultry dressing and evisceration procedures as practiced in their area. The major interest in this work involved the changes taking place after the birds reached the eviscerating line. Average counts of 49,000 per cm^2 were reported for birds as they were placed on the eviscerating line, and 38,000 per cm^2 after evisceration. They recommended that processors avoid storage of several carcasses in the same receptacle, and that evisceration should be accomplished as soon after killing as possible in order to maintain low bacterial loads.

Gunderson *et al.* was interested in types of organisms present that might be of public health significance.

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Members of the genus *Salmonella* were isolated from the viscera, or from equipment directly or indirectly contaminated by viscera or intestinal contents; however difficulty was encountered in isolating salmonellae from the skin surfaces. Also, they reported the isolation of staphylococci and beta-hemolytic streptococci.

The purpose of this study has been to determine the types and loads of organisms encountered on poultry during dressing and eviscerating since it is during these operations that the organisms prevalent on the final product may be introduced and disseminated. In addition, an attempt has been made to study the role, if any, that these organisms have in the spoilage of poultry stored at low temperatures.

Experimental Methods

Samples were taken from the production lines of six different processing plants. The surfaces of the birds were sampled by the swab technique. Absorbent, wet cotton swabs were firmly rolled over 2 cm^2 of surface delineated by sterile metal guides (figure 1). This method lent itself well to taking samples on the processing line. Samples of the cavity of the bird were also taken by a modification of this method. Thin-wall metal tubing of known cross-sectional area was inserted into the cavity to guide the swab and to prevent contact with areas other than those from which the sample was to be obtained (figure 2). One-ml samples of scald and chill tank water were taken. Peptone water blanks (peptone, 0.1 per cent; and NaCl 0.5 per cent) were used to maintain the samples until they were plated.

Various media were used to obtain an indication of the numbers and types of organisms present. Total counts of organisms were determined on nutrient agar incubated at 15 C. Experiments showed that this temperature gave maximum numbers of colonies. The plates were counted within 3 to 4 days. Malt agar, acidified to pH 4.5 and incubated at 30 C, was the medium on which yeast counts were made. Staphylococcus medium No. 110 incubated at 37 C was used to detect the presence of micrococci. An estimate of the number of coliforms present was determined by the most probable numbers technique as described in the *Standard Methods for the Examination of Dairy Products* (APHA, 1948).

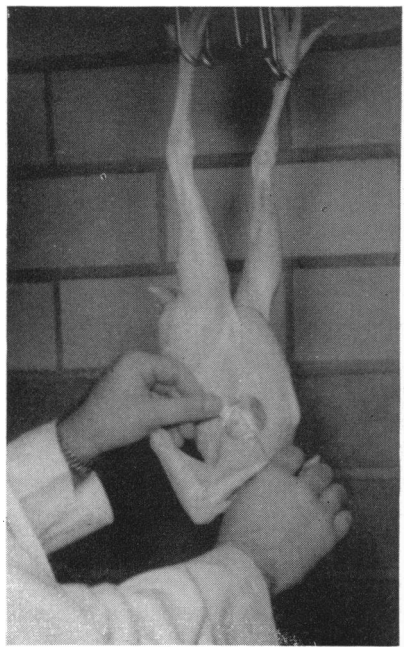

FIG. 1. Aluminum metal disk and swab used for determining numbers of organisms on surface of birds on processing line.

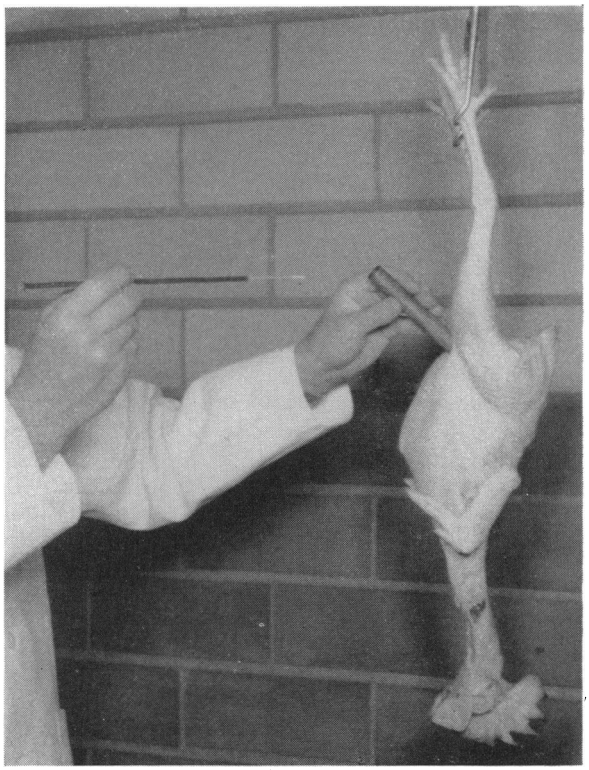

FIG. 2. Swab stick holder, swab stick, and thin-wall metal tubing for sampling bird's visceral cavity while on processing line.

For the detection of salmonellae, selenite F enrichment broth was incubated for 16 to 18 hr at 37 C. The enrichment broth was streaked on brilliant green agar and bismuth sulfite agar. All colonies that showed positive tests for *Salmonella* on these agars were further characterized by inoculation into lactose broth and by agglutination with polyvalent antisera.

In addition to the birds on the processing line, birds stored at 4.4 $\pm$ 2 C were sampled using the methods described above. These birds were stored in evacuated polyethylene bags and sampled every other day for a period of approximately 2 weeks.

The various stations at which samples were taken on the processing line were as follows: (1) the live bird, (2) the scald tank water, (3) after the rough picker, (4) after the neck picker, (5) after pinning, (6) after

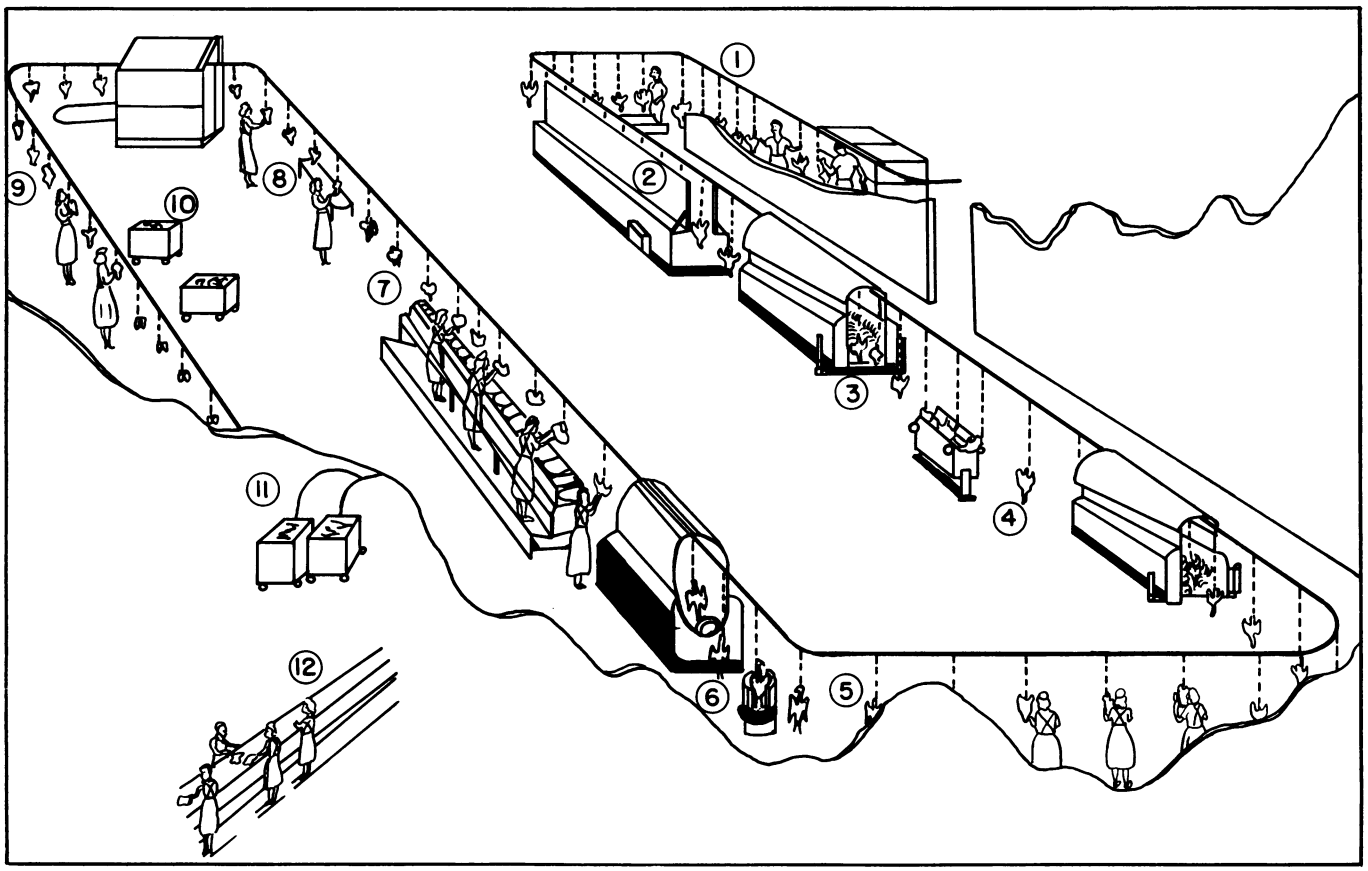

FIG. 3. Schematic diagram of poultry processing plant showing stations at which samplings were taken

singeing, (7) the cavity of the bird, (8) after evisceration, (9) the bird as it was placed in the chill tank, (10) the fresh chill tank water, (11) the aerated chill tank water and (12) the final product after chilling. These stations are shown in figure 3.

RESULTS AND DISCUSSION

A logarithmic plot of the number of organisms found at the various stages of processing is shown in figure 4. Since medians give a less biased estimate than average values, the points shown are medians. The points represent a minimum of 30 samples taken at each station; as many as 40 samples were taken of the scald tank and chill tank waters. The skin of the live bird was found to have a count of about 1500 organisms per cm^2, whereas the final product had a count of approximately 35,000 per cm^2 of skin surface. In general, there was a tendency for the counts to increase during the processing operation.

This general increase in numbers of organisms during processing is somewhat at variance with the results reported by Gunderson *et al.* (1954) and Drewniak *et al.* (1954). This difference might be attributed to a difference in sanitary conditions of the plants in their trials as compared with those plants in the present study.

Since the water samples are expressed in numbers per ml, they are shown separately by the broken line. Counts of 8200 organisms per ml were encountered in the scald tank water and more than 200,000 per ml in the chill tank waters. The low counts obtained in the scald tank water can probably be attributed to the low counts found on the live birds, and possibly the temperature of the scald tank had some bactericidal effect. The temperature range of the scald tanks was 137 to 140 F (58.3 to 60 C). However, by the time the birds have reached the chill tank they have received much handling, and possibly have been contaminated with organisms from the feet, feathers, feces and viscera.

The organisms distributed from these sources would cause high numbers in the chill water.

Variations occurred in the counts from the six plants. Table 1 shows the variations observed. The counts are shown as the highest, lowest, and usual range. The usual range was chosen arbitrarily as that wherein all counts were included except for the lowest 10 per cent and the highest 10 per cent; that is, 80 per cent of the samplings. Total counts on the final product ranged from 4000 per cm^2 of skin surface in one plant to 330,000 per cm^2 in another.

Total bacterial and coliform populations were determined for the cavity of birds immediately after evisceration. Table 2 gives a comparison of these counts with counts found on the outside surfaces of birds being processed at the same time. In general, samplings of

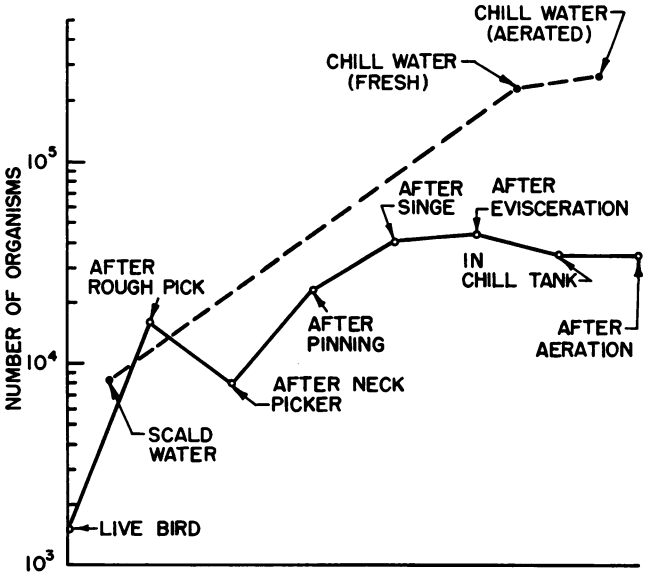

FIG. 4. Median populations recovered from the skin of chickens at various stages of processing or from the scald and chill waters.

TABLE 1. *Numbers of viable organisms recovered from skin surfaces of birds or from scald or chill waters*

Sample	Number of Organisms ($\times 10^2$)*		
	Lowest	Usual range	Highest
Live bird	0.5	0.6–8.1	54
After rough pick	2.4	8.1–45	130
After neck pick	2.6	3.3–32	54
After pinning	3.7	10–84	90
After singe	5.2	13–210	230
After evisceration	8.2	11–93	140
In chill tank	2.9	50–600	760
After aeration	0.7	3.4–240	890
Scald water	4.2	5.9–17	22
Chill water (fresh)	13	50–210	1300
Chill water (aerated)	20	34–240	1500

* Number of organisms per cm^2 on skin as determined by swab method; number per ml in water as determined by dilution procedure.

bacterial populations in the visceral cavity revealed that the loads recovered were lower than those obtained from the skin. Unusually high counts for the visceral cavity were obtained from one plant. On this processing line, the crop removal involved flushing the incision with water. Apparently, blood and other debris were washed into the cavity and resulted in high counts. The number of coliforms found in the cavity tended to be higher than the number found on the outer surface. The coliform counts on the outer surface ranged from zero to 350 per cm^2. These counts are in fair agreement with those reported by Gunderson *et al.* (1954) for birds that have undergone evisceration.

Since salmonellae are frequently associated with poultry and poultry products, attempts were made to isolate any that might be present. Although both the outer skin and cavity surfaces were examined for *Salmonella*, none were successfully isolated. Gunderson *et al.* (1954) indicated that the source of *Salmonella* was the viscera and intestinal contents. Thus, it might be reasonable to assume that any salmonellae appearing on the skin of the birds would be the result of handling or of washing the organisms onto the surface. However, with the development and use of more effective means of isolation, it may become apparent that they are more prevalent than this study has indicated.

Figure 5 depicts the increase in growth of the organisms during storage at 4.4 C in polyethylene bags. Median points rather than average values are shown for 0, 1, 2, 4, 6, 8, 10, and 13 days of storage. The vertical lines indicate the limits within which the counts fell. A typical growth curve was obtained with a lag in growth for about the first 2 days, followed by logarithmic development and negative growth acceleration. The

TABLE 2. *Number of viable organisms recovered from the visceral cavity of birds while on the processing line. Total number of organisms and of coliforms per cm^2 as determined by the swab method.*

Cavity	Number of Organisms ($\times 10^2$)		
	Lowest	Usual range	Highest
Cavity			
Total count	0.3	1.4–12	54–93*
Coliform (MPN)	0	0.02–2.4	>2.4
Outer surface			
Total count	3.4	4.0–93	103
Coliforms	0	0–0.35	0.35

* Results from one plant.

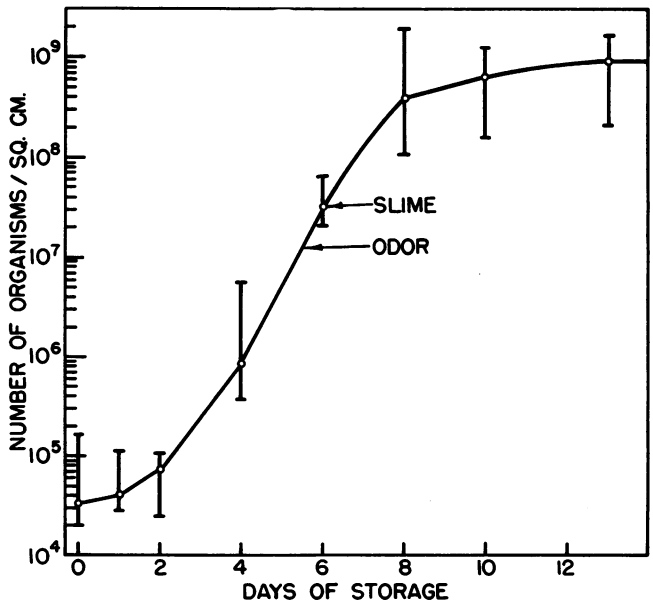

FIG. 5. Relation of viable bacterial population, off-odor, and slime to storage time of dressed chicken stored at 4.4 C.

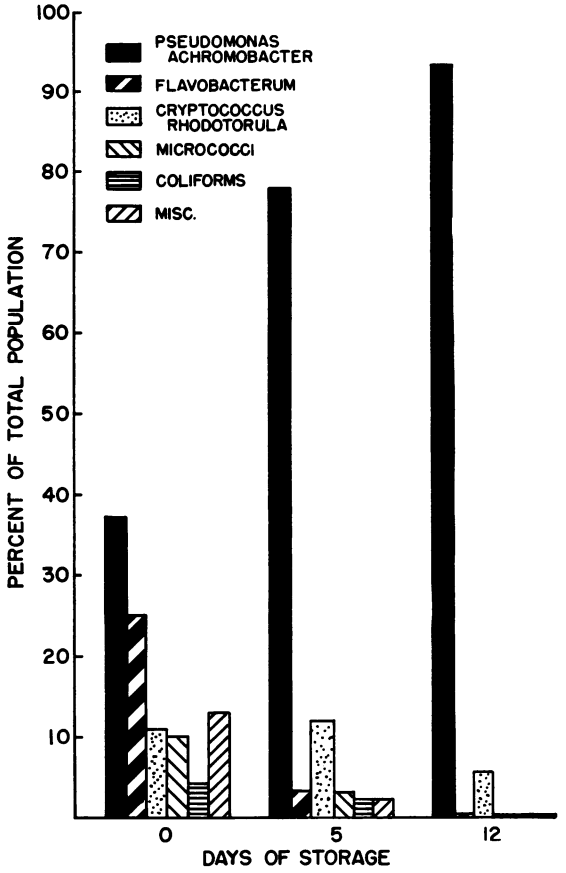

FIG. 6. Effect of storage at 4.4 C on organisms associated with dressed poultry.

arrows indicate the time that undesirable odors and slime occurred. Undesirable odors were detected prior to slime development; both were generally evident within 6 days.

Under the conditions of storage, one would expect requirements to be more favorable for some organisms than for others. Figure 6 gives a breakdown by per cent of the types of organisms present at various stages of storage. Chromogens made up as much as 25 per cent of the initial population. These consisted mainly of organisms with characteristics of *Flavobacterium;* occasionally micrococci were found. After 4 to 5 days, there was a decrease in numbers of these organisms, and by the end of the storage period they were seldom recovered.

As was indicated previously, the coliforms made up a very small proportion of the initial population and tended to decrease during storage.

Yeasts occurred at levels of about 1000 per cm^2, and increased to levels of approximately 100,000 per cm^2 after storage for 2 weeks. No sporulation of these yeasts was found on malt agar, V-8 juice agar, Gorodkowa's agar, and Czapek's agar. On simple carbohydrate media no production of acid was noted, although growth did occur. Some of these yeasts had red pigment and were identified tentatively as *Rhodotorula;* the others were nonpigmented and had biochemical characteristics similar to those of *Cryptococcus* (*Torulopsis*). These yeasts have not been sufficiently characterized to definitely classify them as to species.

The majority of the organisms present had characteristics of organisms identifiable as *Pseudomonas* or *Achromobacter*. They grew well at 4.4 C and outgrew the other organisms less favored by this temperature. At the time that off-odor and slime appeared, these organisms constituted almost the entire population. Ayres *et al.* (1950) reported also that organisms of the *Pseudomonas-Achromobacter* group were responsible for off-odor and slime on eviscerated, cut-up poultry.

Since the predominant organisms are usually found in soil and water, it would be logical to assume that the main sources of the contaminants are the soil and filth on the feet and feathers, and the fecal material and the intestinal contents of the birds. The skin of the bird might be a contributing factor, but the results obtained in this study seem to eliminate it as a major source of contamination. Thus, it appears that washing and handling of the birds acts to disperse the organisms carried into the processing plant on the birds. Any practice that reduces the contribution from any of these sources would result in a reduced number of organisms on the final product.

SUMMARY

An increase in the numbers of organisms present on the surface of birds during processing occurred which can be attributed to the distribution by washing and handling of organisms occurring on the feet and feathers, and in the feces and intestinal contents. Ordinarily, the load ranged between 20,000 to 160,000 per cm^2 with a median of 32,000 per cm^2.

Storage of poultry at 4.4 C in polyethylene bags generally resulted in spoilage in from 4 to 6 days and was associated with organisms with characteristics of the *Pseudomonas-Achromobacter* group. The other organisms present could not compete well at this temperature and the *Pseudomonas-Achromobacter* group constituted almost the entire population at the end of storage.

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