Production of Bacterial Aerosols in a Rendering Plant Process

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DURING AN OUTBREAK of ornithosis in the area of Portland, Oreg., approximately 60 people were infected with the virus between February 15 and March 15, 1956. Two deaths occurred.

The source of the disease was determined to be infected turkeys from two ranches a few miles northwest of Portland. On these ranches, a large number of birds had died of unknown cause just prior to, and during, this period. The cause was later found to be ornithosis. Several hundred of these ornithosis-infected turkeys were processed by an animal-rendering plant on the northern outskirts of Portland between January 1 and March 9, 1956. During this period, part of the plant's normal staff of 18 persons became ill with what was thought to be influenza or some other nonspecific respiratory infection and more people were either hired or borrowed from a nearby plant.

A total of 32 different persons worked in the plant in the 10-week period during which the turkeys were processed. The investigation indicated that 24 employees showed symptoms of ornithosis (*1*). Some of these people were under hospital treatment as late as March 22, 1956. Serologic investigation revealed that 25 of 30 tested had an antibody titer against ornithosis antigen.

Dr. Samuel Osgood of the Oregon State Board of Health, who inspected the rendering plant, suggested that the method of processing the animals may have created aerosols of the virus, causing the high incidence of infection.

To test this hypothesis, the board requested aid from the Biological Warfare Assessment Directory (BWAD) at Dugway Proving Ground, Dugway, Utah, in studying the rendering process and determining (*a*) whether the aerosols of infective organisms may be created by the processing of diseased animal tissue, and if so, (*b*) at which point such aerosols are heaviest, and (*c*) the precautions necessary to prevent a recurrence of infective aerosol production. The author was sent to Portland with the necessary equipment for making this study.

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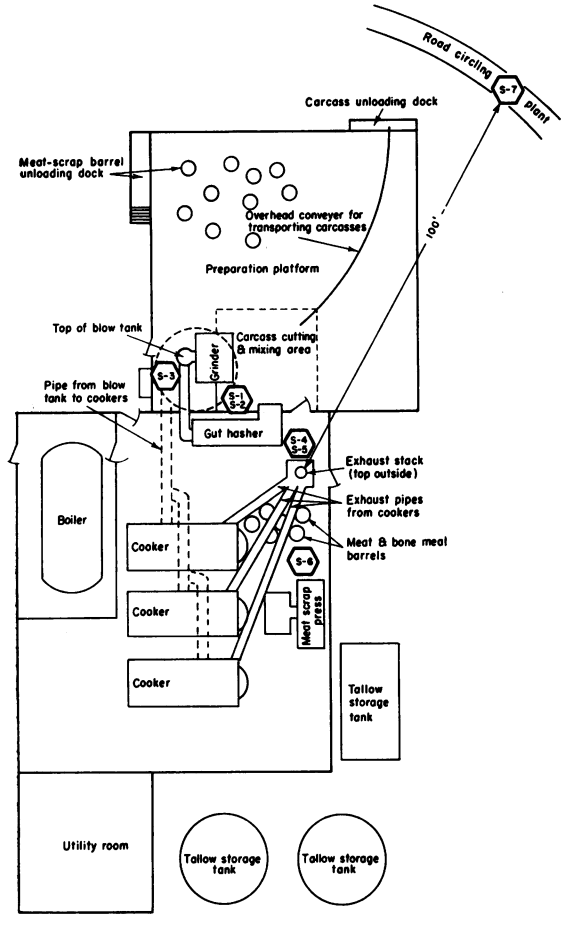
The Rendering Process

The animals to be processed are received at the west end of the building at the carcass unloading dock (see chart). The carcasses are then attached to an overhead conveyor and pulled into the building. Immediately inside the door, the animal is skinned and pulled further into the room where it is lowered to the floor and cut into pieces with a double-bitted axe. These pieces, together with other animal parts brought to the plant in barrels, are fed through a grinding machine into a "blow tank."

Offal obtained from the carcasses and from nearby meat packing plants is fed into a "gut hasher" where the animal feces are removed before these tissues are fed into the blow tank. It appeared rather obvious that aerosols of in-

testinal bacteria were being created by the gut hasher. When the blow tank is full, a small amount of steam is fed into the tank to melt some of the fat. This melted fat helps lubricate the material while it is being transferred to the cookers. The material is transferred to the cookers via a 6-inch pipe by the application of air pressure at the top of the blow tank. Air in the cookers is displaced and passes out of the

Functional Units of Rendering Plant



⬡ indicates position of an Andersen sampler

exhaust pipes to a small stack on top of the building. During the time that most of the material is being "blown" to the cookers, the stack is steaming gently. A water washdown inside the stack, that supposedly keeps material from the blow tank and cooker from escaping into the atmosphere, contributes particulate matter to the steaming. Toward the end of the blowing process a visible water spray erupts from the stack, probably caused by the air pressure in the exhaust pipes.

The ground material is cooked for about 1 hour at 250° F., after which the tallow is collected and placed in storage tanks at the east end of the building. The remaining cooked material is then placed in a press which extracts most of the remaining tallow and dries the resulting meat and bone meal. This meal, which resembles furnace ashes and clinkers, is then placed in open barrels and transported to feed or fertilizer processing plants.

Materials and Methods

Tracer Bacteria

To determine the production of aerosols by the rendering process, chromogenic bacterial slurries (*Bacillus globigii* and *Serratia marcescens*) were prepared and painted on carcasses or sprinkled on the material in barrels before processing began. These two tracer organisms were chosen not only because of their pigment production but also because *S. marcescens* is a vegetative form, showing little resistance to heat and drying by aerolization, while *B. globigii* is a spore-forming organism more resistant to heat and drying.

A total of 4 trials were conducted: two *S. marcescens* trials using approximately 2 quarts of slurry containing 10^{10} organisms per milliliter and 2 *B. globigii* trials using approximately 2 quarts of slurry containing 10^{6} organisms per milliliter.

Sampling Procedures

Aerosol production was determined with the standard Andersen sampler, essentially a cascading sieve sampler which separates the particles of an aerosol into various size ranges and permits culturing for easy counting of colonies developing from viable organisms. The samplers were operated with a flow rate of 1 cubic foot per minute.

Seven samplers were used in each trial in locations within and outside the plant. These samplers were timed to operate during various phases of the rendering process as indicated in table 1.

Table 1. Sampler location and length of sampling interval

Sampler No.	Sampler location [1]	Sampling began	Sampling ended	Approximate operating time (minutes)
S–1	Between grinder and gut hasher	After application of tracer organisms to the animal material	5 minutes later (before beginning of grinder operation)	5
S–2	Between grinder and gut hasher	At the beginning of the grinding operation	At the end of the grinding operation	35–45
S–3	Near top of blow tank	At the beginning of the grinding operation	At the end of the grinding operation	35–45
S–4	Near top of exhaust stack	At the beginning of the steaming from the exhaust stack	Just before water-spray eruption from exhaust stack	5–20
S–5	Near top of exhaust stack	At the beginning of the water-spray eruption	5 to 10 minutes after the end of the water-spray eruption	5–10
S–6	Between cooker and meat-scrap press	Trial 1: At the beginning of the cooking operation	60 minutes later	60
		Trials 2, 3, and 4: At the beginning of the pressing operation of the preceding run	At the midpoint of the following cooking operation	30–60
S–7	Approximately 100 feet downwind from exhaust stack	At the beginning of the steaming of the exhaust stack	At the end of the water-spray eruption	10–25

[1] Field control, taken to determine whether the method of applying the tracer organisms created an aerosol. Limitations of time and equipment precluded the taking of field controls at other points in the plant.

Culturing Procedures

Air samples were collected on nutrient agar which had a pH of 6.5 and was enriched with 1.0 percent glucose and 0.5 percent starch. The enrichments in the nutrient agar enhanced the pigment formation by the tracer organisms. The plates from the *S. marcescens* trials were incubated for 48 hours at 26° C., while those from the *B. globigii* trials were incubated for 48 hours at 37° C. The lower temperature for the *S. marcescens* is necessary for that organism's developing maximum pigment formation.

Results

The four trials were completed during one 8-hour-day operation at the rendering plant. The two *S. marcescens* trials were conducted first but were not completely successful because other microbial forms, probably intestinal bacteria together with molds and yeasts, crowded out the *S. marcescens*. However, some *S. marcescens* were recovered at all seven sampling positions, with the highest discernible counts in the vicinity of the grinder. These data are not presented here because the masking effect of overgrowth by other forms precluded any accurate counts. During the *B. globigii* trials, a large number of *S. marcescens* were collected, perhaps from residual agent left in the grinder since the control count before the trial was low. Overgrowth of other forms was not so extensive in the *B. globigii* trials, probably because of the higher incubation temperature. Data from both *B. globigii* trials are presented in tables 2 and 3.

Discussion

As expected, the highest counts were obtained in the area of the grinder and blow tank, which, together with the gut hasher, are undoubtedly the foci of heavy aerosols arising from the processing of animal tissue. The fact that *S. marcescens* survived from its first application through the *B. globigii* trials indicates that little in the initial phases of the rendering process is detrimental to vegetative forms and, therefore, that these initial phases were probably not any more harmful to the ornithosis virus. Since infected birds or mammals probably contain many times more infective organ-

isms than the number of tracer organisms used in any one trial in this investigation and since most or all of the turkeys processed in the rendering plant were probably infected with ornithosis, the aerosols of this organism were most likely extremely heavy on the days the turkeys were processed. Such an assumption would account for the high incidence of infection in plant personnel.

The cookers should destroy all pathogenic forms because of the extended time that the material is subjected to high temperatures; therefore, a fine dust arising from the meat and bone meal press was probably sterile. This theory was confirmed, somewhat, by the fact that sterile dust was collected on the sixth stage of sampler S–6 placed in the cooker room.

The relatively high number of *S. marcescens* collected, as compared to *B. globigii*, was probably due to the wide difference in the initial slurry counts, 10^{10} and 10^{6} organisms per milliliter, respectively.

Table 2. Recovery of Bacillus globigii (BG) and Serratia marcescens (SM) from aerosols created by processing animal carcasses painted with bacterial slurry through a rendering plant—trial 3

Sampler No.	Position	Organism sampled	Total number organisms recovered	Air sampled, cubic feet	Organisms per cubic foot of air sampled
S–1	Control [1]	BG	4	8	0. 5
S–1	do	SM	4	8	. 5
S–2	Grinder	BG	Sample lost		
S–2	do	SM	do		
S–3	Blow tank	BG	24	35	. 69
S–3	do	SM	446	35	12. 74
S–4	Stack (steaming)	BG	0	5	0
S–4	do	SM	0	5	0
S–5	Stack (blowing)	BG	10	5	2. 00
S–5	do	SM	2	5	. 40
S–6	Cooker	BG	48	40	1. 20
S–6	do	SM	191	40	4. 78
S–7	Downwind	BG	3	10	. 33
S–7	do	SM	5	10	. 50

[1] The control sampled only the background in the vicinity of the grinder and blow tank after the slurry was painted on the animal carcasses.

Table 3. Recovery of Bacillus globigii (BG) and Serratia marcescens (SM) from aerosols created by processing animal carcasses painted with bacterial slurry through a rendering plant—trial 4

Sampler No.	Position	Organism sampled	Total number organisms recovered	Cubic feet of air sampled	Organisms per cubic foot of air sampled
S–1	Control [1]	BG	Sample lost		
S–1	do	SM	do		
S–2	Grinder	BG	193	45	4. 29
S–2	do	SM	498	45	11. 67
S–3	Blow tank	BG	59	45	1. 31
S–3	do	SM	229	45	5. 09
S–4	Stack (steaming)	BG	11	20	. 55
S–4	do	SM	10	20	. 50
S–5	Stack (blowing)	BG	24	10	2. 40
S–5	do	SM	9	10	. 90
S–6	Cooker	BG	9	30	. 30
S–6	do	SM	31	30	1. 03
S–7	Downwind	BG	5	15	3. 33
S–7	do	SM	3	15	. 20

[1] The control sampled only the background in the vicinity of the grinder and blow tank after the slurry was painted on the animal carcasses.

The data presented herein are little more than qualitative in nature because of the interference from other microbial forms also present as aerosols, and because of the fact that no determination could be made as to whether the aerosol collected was homogeneous throughout the sampling period or whether the concentration varied considerably with time. In any future investigations the homogeneity of the aerosol could be determined with slit samplers.

When it was recommended that all material be heated before it was processed, the plant manager stated that this process would ruin the hides. The hides apparently represent a rather larger proportion of the profit from an operation of this type. The author recommended that, in lieu of initial heating, the material be heated by steam under pressure immediately after the skinning operation and before it is processed through either the grinder or the gut hasher. It was also recommended that the gut hasher and grinder be covered or in some way redesigned to minimize aerosol production.

Since the tracer organisms used in these trials are not found naturally in the atmosphere, organisms recovered from the stack and at a position downwind from the stack must have come from the plant. This being true, the processing of diseased animal tissues by this type of rendering plant represents a hazard to people in surrounding areas, as well as to the normal working staff of the plant. Some of the animals processed might have died of any one of a number of animal diseases that may infect man. These include besides ornithosis: anthrax, brucellosis, tularemia, glanders, sylvatic plague, Q fever, and virus equine encephalitis. A study of the antibody titer to these diseases in rendering-plant personnel and nearby permanent residents should be of interest to many health departments since aerosols of such infective organisms may represent a potential hazard to almost every community of any size in America.

Conclusions and Recommendations

From the study of the aerosol production in an animal rendering plant, the following conclusions have been drawn:

1. The rendering process does create aerosols;
2. The heaviest concentration of aerosols appears to be in the vicinity of the grinder and the gut hasher;
3. Vegetative organisms persist in the grinder and gut hasher after these machines have been initially inoculated;
4. Both vegetative and spore-forming organisms survive the blowing operation and are released into the atmosphere; and
5. Both vegetative and spore-forming organisms can be recovered 100 feet downwind from the exhaust stack.

From the conclusions of this study, it is recommended that:

1. All animal material other than hides be heated prior to processing; and
2. Plant machinery be redesigned to minimize aerosol production.

REFERENCES

(*1*) Osgood, S. B., and Holmer, M.: An outbreak of psittacosis in Oregon. *In* Proc. International Conference on Diseases in Nature Communicable to Man, 11th annual meeting, 1956. In press.

Symposium on Venereal Disease

The eighth annual symposium on Recent Advances in the Study of Venereal Diseases will be held in the auditorium of the Department of Health, Education, and Welfare, Washington, D. C., on April 24–25, 1957. The sessions are open to all interested physicians and workers in allied professions.