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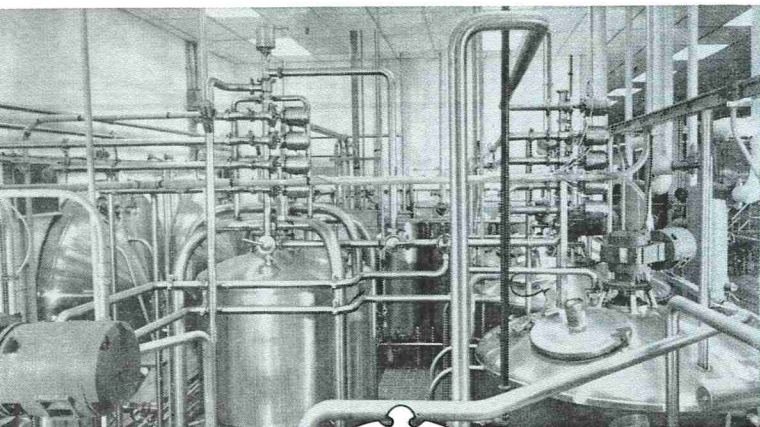
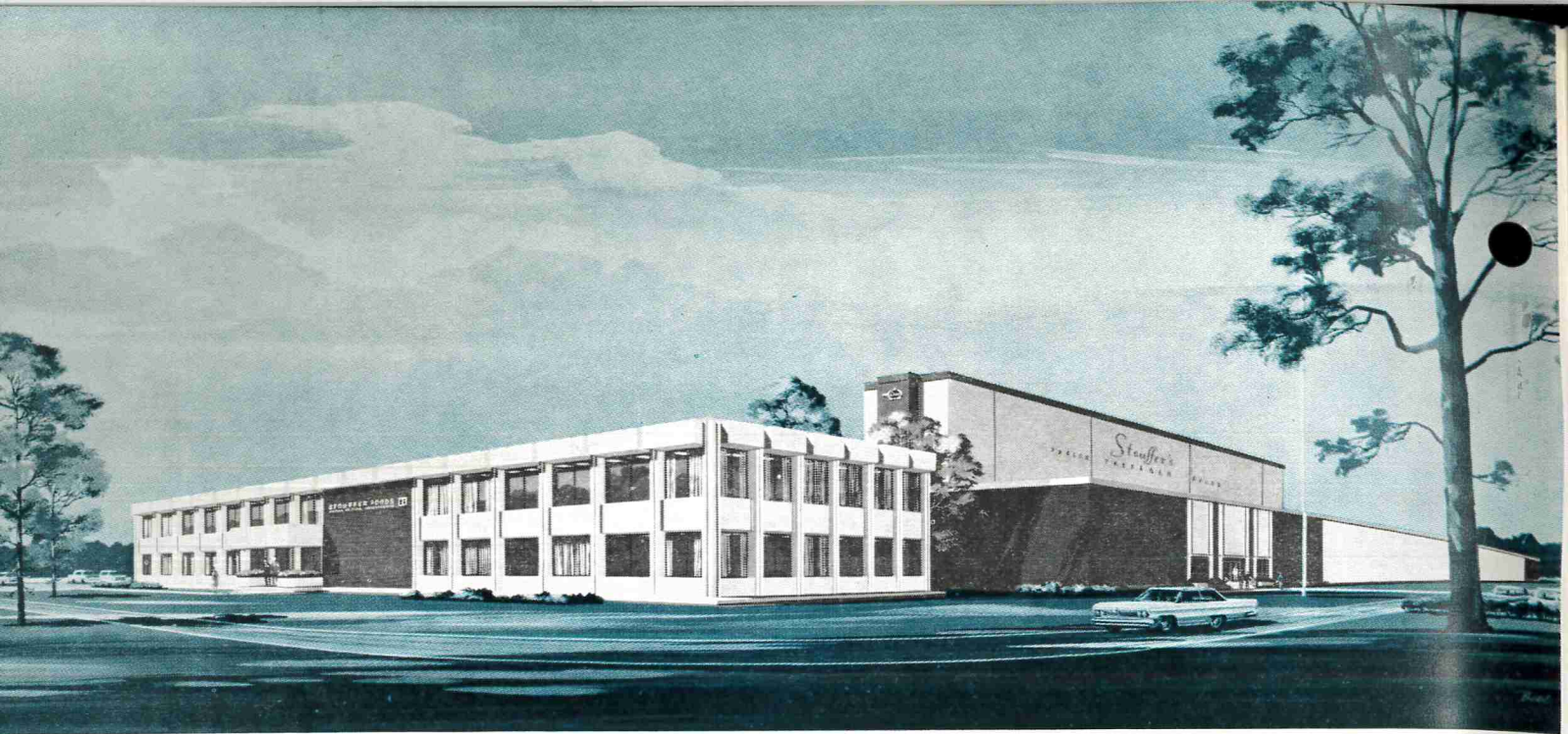
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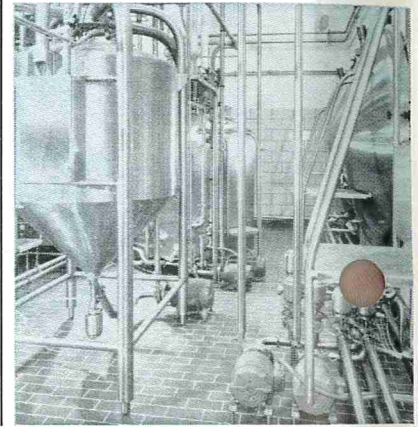
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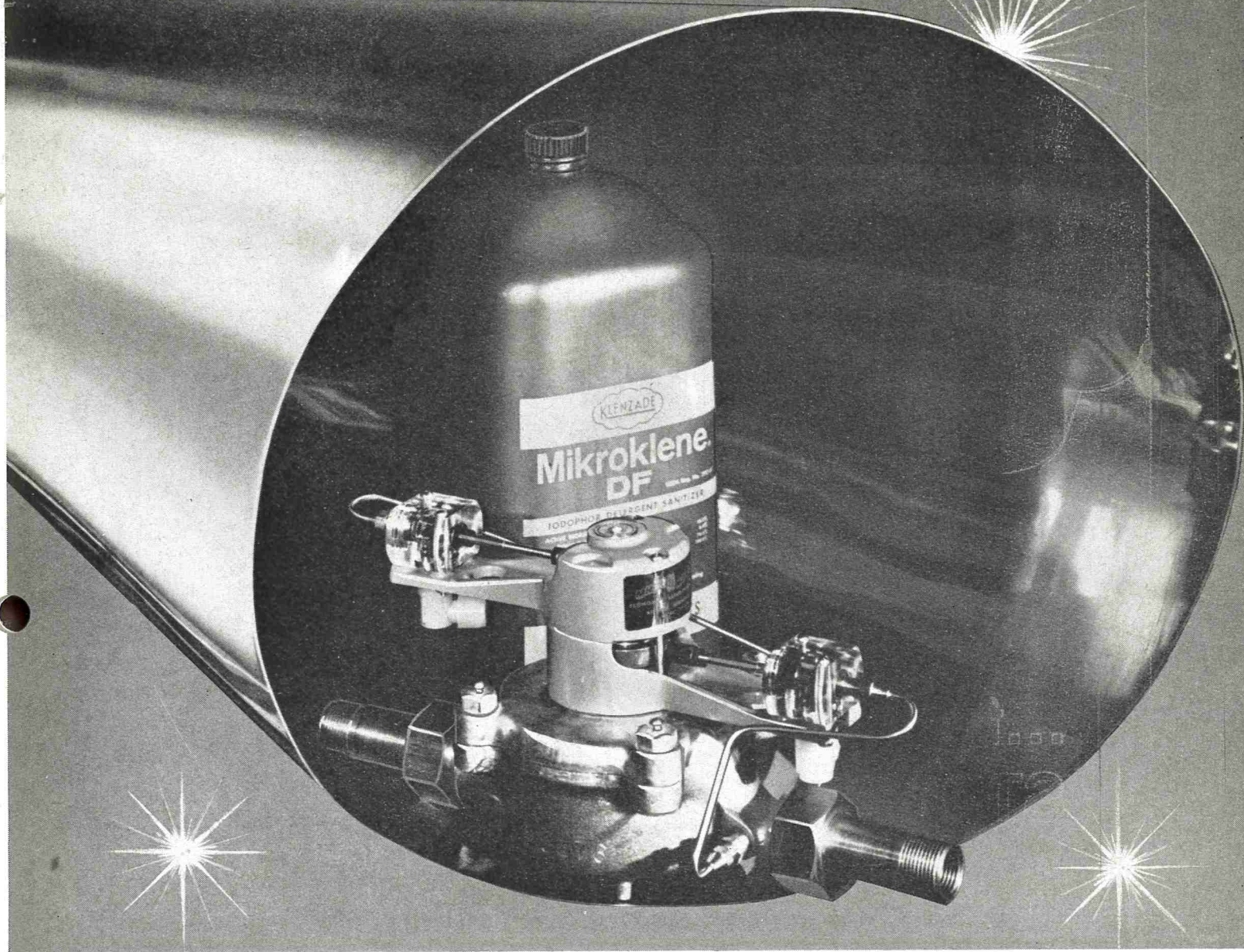
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Clostridium Perfringens Food Poisoning <i>C. L. Duncan</i> -----	35
An Evaluation of the Salmonella Problem: Summary and Recommendations— <i>Committee on Salmonella National Academy of Sciences— National Research Council</i> -----	42
New York City's Rat Control Program <i>Murry H. Raphael</i> -----	52
A Stable Milk-Like Emulsion for Milko-Tester Check Purposes <i>Manfred Kroger</i> -----	58
Thermodestruction of Bacillus Spores in Milk <i>E. M. Mikolajcik</i> -----	61
Egg Processing Technology—Progress and Sanitation Programs <i>Richard H. Forsythe</i> -----	64
Association Affairs -----	73
New and Events -----	75
Index to Advertisers -----	V

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CLOSTRIDIUM PERFRINGENS FOOD POISONING^{1, 2}

C. L. DUNCAN

Food Research Institute and Department of Bacteriology
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ABSTRACT

Clostridium perfringens type A food poisoning in man is characterized by diarrhea and abdominal pain. The disease usually follows ingestion of food contaminated with large numbers of *C. perfringens* cells. During the past 3 to 5 years, the role of this organism in food poisoning incidents in the United States has acquired new emphasis as a result of the increasing number of reported outbreaks and the alarming number of cases associated with these outbreaks. In 1968, *C. perfringens* was responsible for approximately 28% of the food poisoning outbreaks and 49% of the cases, when compared with food poisoning caused by *Salmonella*, *Staphylococcus*, *Shigella*, and *Clostridium botulinum*.

The majority of reported outbreaks and cases resulting from *C. perfringens* are associated with mass feeding establishments. The most common vehicles are beef and poultry products. The mode of action by which *C. perfringens* causes food poisoning symptoms is not fully understood. Control of this type of food poisoning must be concerned with prevention of spore germination and/or multiplication of the vegetative cells in cooked foods.

As early as 1945, McClung described an outbreak of human food poisoning in the United States resulting from the ingestion of boiled chicken contaminated with *Clostridium perfringens* (19). However, it was not until 1959 that official epidemiological reports were received of food poisoning outbreaks in which *C. perfringens* type A was identified as the etiological agent (2). Although only 4 outbreaks were reported that year, belated recognition was at last made of a food poisoning organism that was the culprit in many food poisoning incidents in England since the early fifties. With the publication of the now classical paper on *C. welchii* (*perfringens*) food poisoning by Hobbs et al. in 1953 (16), it became obvious that here was an organism that seemed to present a particular hazard to the food service industry. All but 2 of the 18 outbreaks of *C. perfringens* poisoning that occurred in the London area from September, 1949 to January, 1952 occurred in school, municipal, or factory canteens. In most instances, large numbers of persons were involved.

During the past 3 to 5 years, the role of this organism in food poisoning incidents in the United States

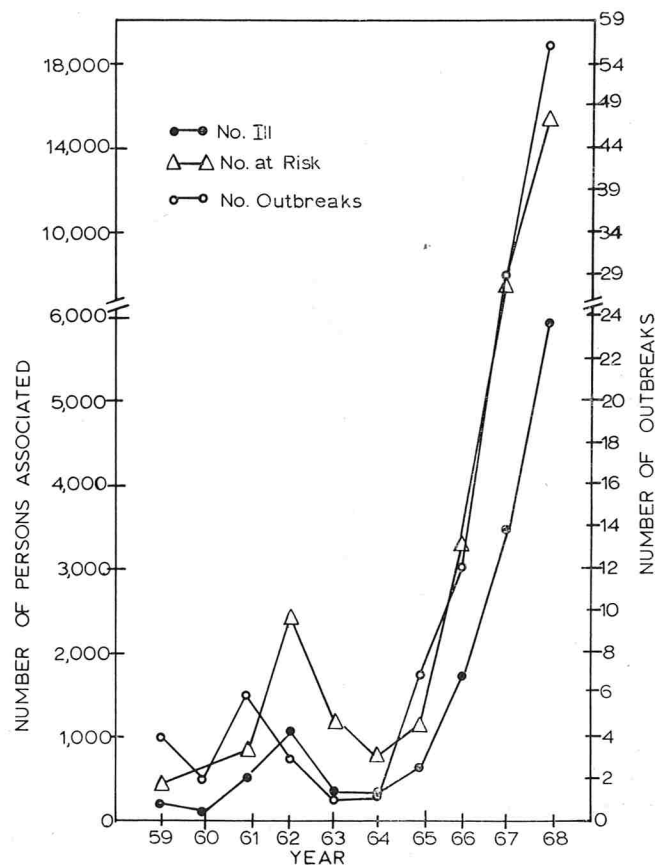


Figure 1. Incidence of food poisoning caused by *Clostridium perfringens* in the United States during 1959 through 1968. Data are based on reports appearing in the following references: 1, 2, 7, 8, 9, 10, 18, 20, 21, 22, 23, 24, 25, 28 and 30.

has acquired new emphasis. This has resulted from the increasing number of outbreaks reported each year and the alarming number of cases associated with these outbreaks. This paper is an attempt to look at the problem of *C. perfringens* food poisoning as it currently exists.

STATISTICS OF OUTBREAKS

The occurrence of food poisoning caused by *C. perfringens* during 1959 through 1968 is shown in Fig. 1. During the period from 1959 to 1964, there were relatively few reported outbreaks related to *C. perfringens*. These few reports were probably made only as the result of the foresight of health laboratories that included *C. perfringens* as a possibility in

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²Presented at the Fifty-sixth Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Inc., Louisville, Kentucky, August 18-21, 1969.

their search for a causal agent. For example, in 1961, 5 of the 6 outbreaks were reported by the state of California alone (18). In fact, in that year in California, *C. perfringens* was responsible for the largest number of food poisoning cases caused by a single known etiologic agent.

After 1964, the number of reported outbreaks began to increase substantially each year, with 29 outbreaks being reported in 1967 and 56 in 1968.

In general, *C. perfringens* outbreaks involve large numbers of individuals. Figure 1 shows both the number of persons actually ill and the number at risk for each year. The values for 1962 were perhaps a forewarning of what was to come. Specifically, 1,093 persons were reported ill out of 2,442 at risk. Hidden in these figures is the fact that in one single outbreak occurring in a mental institution in the state of California, about 900 of 2,227 patients were ill (18). The values for 1968 are 5,966 ill and 15,698 at risk. The largest outbreak of 1968 occurred on September 14, in New York City, among members of a company that had consumed a banquet dinner of roast beef at a hotel. Of 1,800 members present at the banquet, it was estimated that more than 560 individuals became ill (10, 26). Clearly then, the potential exists for a larger number of persons to be affected by perfringens food poisoning.

The increase in the number of reported outbreaks in the past few years probably results from an increased recognition of the organism as a food poisoning agent. Public health laboratories have become aware of the potential of *C. perfringens* to cause food poisoning. Consequently, they are looking for and finding the organism to be the causative agent in many outbreaks that in previous years would have been placed in the "cause unknown" category.

The question may be asked, "How does the frequency of *C. perfringens* poisoning compare with that of such notorious food poisoning organisms as *Salmonella* and *Staphylococcus*?" Table 1 presents a comparison of the incidence of perfringens outbreaks and cases with those of 4 other etiologic agents—*Salmonella*, *Staphylococcus aureus*, *Clostridium botulinum*, and *Shigella*. The values presented are the percentages of the total outbreaks or cases reported for only these 5 different agents. During 1959, 1960, and 1961, *Staphylococcus* was clearly responsible for the majority of both outbreaks and cases with *Salmonella* being second in frequency. *Clostridium perfringens* was third or fourth in frequency. However, in 1966 the frequency pattern changed. Although *Staphylococcus* was still responsible for the greatest percentage of outbreaks, the greatest percentage of cases (40%) was attributed to *C. perfringens*. In 1967, 68.3% of the cases were attributed to mem-

Year	<i>Clostridium perfringens</i>	<i>Salmonella</i> species	<i>Staphylococcus aureus</i>	Botulism	<i>Shigella</i> species
	— — — — % of Total — — — —				
1959	3.2	15.3	71.8	8.1	1.6
	3.8	24.4	70.7	0.4	0.6
1960	2.7	21.6	68.9	0.0	6.8
	3.0	17.2	57.3	0.0	22.5
1961	7.4	24.7	56.8	7.4	3.7
	17.7	25.3	50.8	0.5	5.7
1966	15.0	31.3	42.5	7.5	3.8
	40.0	37.0	20.9	0.3	1.7
1967	22.1	30.5	42.0	0.0	5.3
	18.5	68.3	10.1	0.0	3.1
1968	28.7	21.5	42.0	4.6	3.1
	49.4	10.6	36.6	0.1	3.4

¹Only confirmed outbreaks included in first 3 years. Both confirmed and unconfirmed included in last 3 years. The values are the percentages of the total outbreaks or cases reported for only these 5 different organisms and are calculated from data appearing in references 1, 2, 7, 8, 9, 10, and 22.

bers of the genus *Salmonella*; however, over 10,000 of these cases (approximately 80% of all the *Salmonella* cases) were associated with only 2 outbreaks. In 1968, for the first time, *C. perfringens* surpassed *Salmonella* in the percentage of total outbreaks. A total of 28.7% of the outbreaks were caused by *C. perfringens*, this being second only to *Staphylococcus*, which was responsible for 42% of the outbreaks. Also for the first time, *C. perfringens* was responsible for the greater number (49.4%) of the total cases.

In England and Wales, *C. perfringens* has been found for some time to be responsible for more cases of food-borne illness than has *Staphylococcus*. A representative comparison of the incidence of *C. perfringens* outbreaks and cases with those of *Salmonella* and *Staphylococcus* that have occurred in England and Wales is shown in Table 2. The majority of the outbreaks and cases were caused by *Salmonella*. *Clostridium perfringens* was responsible for approximately 2% of the outbreaks and generally about one-fourth of the cases. Although *C. perfringens* was responsible for only about 2% of the outbreaks, the actual number of outbreaks has not fallen below a total of at least 63 per year since 1955 (20,

TABLE 2. COMPARISON OF ETIOLOGICAL AGENTS CAUSING FOOD POISONING OUTBREAKS IN ENGLAND AND WALES¹

Year		<i>Clostridium perfringens</i>	<i>Salmonella</i> species	<i>Staphylococcus aureus</i>
		-- -- % of Total -- -- --		
1959	Outbreaks	2.1	95.7	2.2
1960	Outbreaks	2.3	95.3	2.4
1961	Outbreaks	2.1	95.6	2.3
1966	Outbreaks	2.4	95.5	2.1
	Cases	20.3	65.6	4.1
1967	Outbreaks	2.4	96.8	0.9
	Cases	28.5	62.8	5.5

¹The values are the percentages of the total outbreaks or cases reported for only these 3 different organisms and are calculated from data appearing in references 36 and 37.

TABLE 3. PLACE OF ACQUISITION OF *Clostridium perfringens* FOOD POISONING OUTBREAKS IN THE UNITED STATES¹

Year	Home	Restaurant	Banquet	Colleges or schools	Health institutions	Other
1959	1	2				1
1960						2
1961	1	1		1		3
1962					2	1
1963				1		
1964				1		
1965	1	1	3	2		
1966	Not Available					
1967	1	9	10	6		3
1968	6	23	8	14	1	4
Total						
Outbreaks	10	36	21	25	3	14
Total						
Cases	82	1,618	4,782	4,089	1,181	1,867

¹Data are based on reports appearing in the following references: 1, 2, 7, 8, 9, 10, 18, 20, 21, 22, 23, 24, 25, 28, and 30.

37). This is higher than the maximum number of 56 outbreaks reported in the United States in 1968.

It is still not known how many outbreaks occur in the United States each year that involve *C. perfringens*. With better reporting of outbreaks and more examination of suspect foods for this organism, it may be found that it surpasses both *Staphylococcus* and *Salmonella* as a causative agent of food-borne illness.

The relationship of these statistics to the food service industry is quite important. In the United States, it has been estimated that 400,000 food service establishments serve about 100,000,000 meals daily. Eighty-two per cent of these meals are served

in public eating establishments; the remainder are served in institutions (34). *Perfringens* food poisoning may occur when the organism grows in a cooked food product prior to consumption. The organism may multiply over a broad temperature range of about 15 to 50 C (59 to 122 F) and over a pH range of about 5.5 to 8.0 (31). Under optimum conditions, large numbers of cells may be produced in 2 to 3 hr. Therefore, the danger lies in keeping food at a temperature that is apparently either hot or cold but is one at which growth of the organism will occur. This hazard may often be present in mass feeding establishments that rely on steam tables or cooling tables for maintaining foods at "safe" temperatures. The hazard may be even greater if foods have been improperly cooled or inadequately reheated before placing on the steam or cold table. Table 3 shows that, indeed, the great majority of *perfringens* food poisoning incidents that are reported by health authorities occur in food service establishments that are concerned with mass feeding.

The table shows the place of acquisition of *perfringens* food poisoning outbreaks in the United States from 1959 through 1968. In addition, the total number of cases associated with each specific place is indicated. The outbreaks reported for banquets were meals that were usually served either in restaurants or school cafeterias, but a specific outbreak is listed under only one heading. The statistics show why such large numbers of persons are associated with *perfringens* food poisoning outbreaks. The majority of the outbreaks and cases were associated with mass feeding establishments with restaurants accounting for the largest number of outbreaks and banquets the largest number of cases. With large numbers of persons eating a common meal, it

TABLE 4. VEHICLES ASSOCIATED WITH *Clostridium perfringens* FOOD POISONING OUTBREAKS IN THE UNITED STATES¹

Year	Turkey	Chicken	Beef	Other Meat	Unknown or other foods
1959	1		1	1	1
1960			2		
1961			3	1	2
1962	2		1		
1963	1				
1964				1	
1965	4		1		2
1966	3	3	5		2
1967	1	3	14	3	8
1968	17	6	24	3	11
Total	29	12	51	9	26

¹Data are based on reports appearing in the following references: 1, 2, 7, 8, 9, 10, 18, 20, 21, 22, 23, 24, 25, 28, and 30.

is easy to recognize when a food poisoning outbreak has occurred at a banquet, college or school cafeteria, or at an institutional or industrial cafeteria. However, with a restaurant or other commercial establishment that serves a transient customer, food poisoning incidents may go undetected. For this reason, the number of outbreaks occurring in restaurants and caused by *C. perfringens* may be substantially higher than is now reported. The same may be true for outbreaks that occur in the home.

Table 4 reports the vehicles associated with perfringens outbreaks during the same 1959-1968 period. With a total of 51 outbreaks, beef was the most common vehicle. Poultry products (including turkey and chicken) were next with a total of 41 outbreaks. Some of the outbreaks resulted from meat and/or gravy and/or dressing. These are the types of foods commonly served in mass feeding establishments. They generally require low temperature cooking, are usually served with a gravy, and may be cooked in advance and reheated prior to serving. Improper cooling of such foods after the initial cooking may allow growth of *C. perfringens* spores that survived the heat treatment. Also, the reheating may not be sufficient to inactivate *C. perfringens* cells or spores which may be present and the temperature may not be maintained high enough to prevent subsequent multiplication of the cells during the actual serving of the food. Such mishandling of foods may be disastrous to those in charge of the food service establishments. Aside from the individual loss, such establishments may suffer from loss of public confidence and even legal action.

THE ILLNESS

Compared with the more familiar types of food poisoning, that caused by *C. perfringens* is less severe and of short duration. Table 5 presents a comparison of the incubation periods and main symptoms of *C. perfringens*, *Salmonella*, and *Staphylococcus* food poisonings. The symptoms of perfringens poisoning usually appear after an incubation period of 8 to 22 hr, compared to 12 to 24 hr for *Salmonella* and 2 to 6 hr for *Staphylococcus*. The clinical illness of perfringens food poisoning is characterized primarily by diarrhea and abdominal cramps. Most patients have acute abdominal pain, while about one-third are affected by nausea and headache. Vomiting, which is common in *Staphylococcus* food poisoning, and fever, which is common in *Salmonella* food poisoning, rarely occur in patients suffering from perfringens food poisoning. In fact, the clinical and epidemiologic pattern of perfringens food poisoning is sufficiently characteristic as to be nearly diagnostic.

TABLE 5. COMPARISON OF THE INCUBATION PERIODS AND MAIN SYMPTOMS OF *Clostridium perfringens*, *Salmonella*, AND *Staphylococcus* FOOD POISONING¹

Characteristic	<i>Clostridium perfringens</i>	<i>Salmonella</i>	<i>Staphylococcus</i>
Incubation	8-22 hr	12-24 hr	2-6 hr
Duration	12-24 hr	1-14 days	6-24 hr
Diarrhea	Extremely common	Very common	Common
Abdominal pain	Present	Present	Present
Vomiting	Very rare	Not common	Extremely common
Fever	Absent	Very common	Absent
Prostration	Common	Rare in early stages	Common

¹After Gilbert, 1969 (11).

TABLE 6. INCIDENCE OF *Clostridium perfringens* IN FOODS

	No. of samples examined	No. of samples positive	Per cent positive samples
<i>Strong et al., 1963 (32)</i>			
Commercially prepared frozen foods	111	3	2.7
Raw fruits and vegetables	52	2	3.8
Spices	60	3	5.0
Home-prepared foods	165	3	1.8
Meat, poultry, and fish	122	20	16.4
<i>Hall and Angelotti, 1965 (12)</i>			
Veal	17	14	82.0
Beef	50	35	70.0
Chicken	26	15	58.0
Lamb	27	14	52.0
Pork	41	15	37.0
<i>Nakamura and Kelly, 1968 (27)</i>			
Spaghetti sauce and mixes	13	7	53.8
Sauce and gravy mixes	8	1	12.5
Soup mixes	28	1	3.6
Cheese and cheese sauce	6	1	16.7

Although death from perfringens food poisoning is rare, several cases have been reported in other countries. These usually have been associated with elderly and/or debilitated persons. For instance, in 1967 two deaths resulting from perfringens food poisoning were reported in England and Wales (37). One who died was a woman aged 58 who also was suffering with diabetic ketosis; the other was a patient aged 42 who died in a hospital outbreak of perfringens food poisoning. Another death that occurred in the London area in 1966 was a 62-year-old woman who died 48 hr after eating turkey contaminated with *C. perfringens* (33). Although the woman was

also suffering from Pott's disease at the time, the cause of death was certified as "acute enterocolitis due to food poisoning."

These facts indicate that even though the symptoms of perfringens food poisoning are usually less severe than those of other agents such as *Salmonella*, death can result in the elderly or debilitated. Outbreaks such as the one caused by *C. perfringens* that occurred in a geriatric hospital in California in 1962 and that involved 38 of 45 patients (20) become of even more concern when the lethal potential is realized.

MECHANISM OF PATHOGENICITY

Clostridium perfringens food poisoning occurs after ingestion of a food containing large numbers of the organism. This fact has been confirmed by several human volunteer experiments (3, 15, 16). The mechanism by which the illness is produced is not clear. However, the requirement that viable cells be ingested for production of symptoms in humans suggests that the mode of action is that of infection. Yet, clinical symptoms themselves, such as the lack of fever, high primary attack rate, lack of secondary person to person spread, and lack of clinical immunity, suggest an intoxication.

Several years ago it was suggested that phosphorylcholine, a product resulting from the hydrolysis of lecithin in the presence of the alpha toxin of *C. perfringens*, was the agent responsible for both perfringens food poisoning and that caused by *Bacillus cereus* (29). Although this was an attractive suggestion, animal feeding studies (38) and human ingestion of phosphorylcholine (Dack, *personal communication*) failed to validate the hypothesis.

An understanding of the illness has been hindered in part by the lack of a readily available laboratory animal in which the food poisoning syndrome could be reproduced. Hauschild et al. (13) have shown that lambs developed diarrhea, the principal symptom of food poisoning in man, after administration of *C. perfringens* cells either orally or intraduodenally via a fistula. Onset and duration of diarrhea in the lambs were essentially the same as in humans after experimental ingestion of the organism. It also was reported that immunization of lambs against alpha toxin prior to challenge had no effect on the ability of the cells to produce diarrhea. A later report (14) showed that fluid accumulation occurred in ligated intestinal loops of lambs when *C. perfringens* cells suspended in fresh medium were injected. Culture supernatant fluid had no effect. Again, their results indicated that alpha toxin was not the factor responsible for fluid accumulation in the loops.

Duncan et al. (6) reported results of an investiga-

tion on the ligated loop of the rabbit intestine as a possible experimental model for the study of perfringens food poisoning. It was found that about one-half of the type A strains tested that were isolated from food poisoning outbreaks consistently produced exudation of fluid in the intestinal loop when the challenge was made with cultures grown for a few hours in a skim milk medium. In contrast, the majority of the strains derived from sources other than food poisoning outbreaks failed to induce a comparable consistent response. In the rabbit, as in the lamb, fluid accumulation was shown not to be caused by alpha toxin. Subsequent studies revealed that overt diarrhea could be experimentally produced in rabbits by injection of viable cells directly into the normal (not ligated) ileum, but not by oral challenge (4). Good correlation was obtained between the ability of the strains to produce fluid accumulation in the ileal loops and overt diarrhea. The ability of a specific strain to induce diarrhea was dependent on both the number of cells in the challenge and the method of preparation of cells for challenge. A challenge of approximately 10^{10} total cells obtained from a sporogenic medium and resuspended in skim milk was most consistent in producing diarrhea. Cells obtained from an asporogenic medium usually would not produce diarrhea.

Additional investigations were made of the ability of cell extracts and concentrated culture filtrates of various strains of *C. perfringens* to produce ileal loop fluid accumulation and overt diarrhea in rabbits (5). Again, good correlation was obtained between the ability of viable cells and of a toxic factor present in cell extracts and culture filtrates to produce both fluid accumulation in ileal loops and diarrhea when injected into the normal ileum of the rabbit. The toxic factor was shown to be heat labile, non-dialyzable, and was inactivated by pronase, but not by trypsin, lipase, or amylase. The toxic factor was present in cell-free preparations when cells were grown in a sporogenic medium but not when they were grown in an asporogenic medium, which correlated with the usual inability of viable cells grown in an asporogenic medium to produce diarrhea. This was the first published report on the repeated production of a diarrhea response in an experimental animal by such cell-free preparations.

Further studies are necessary to determine if the diarrhea-producing factor active in rabbits is associated with diarrhea production by *C. perfringens* in cases of human food poisoning. If the agent active in both humans and rabbits is one and the same, the failure to obtain food poisoning symptoms in humans fed culture filtrates of *C. perfringens* (3) may have resulted from the low concentration of the

active factor present in culture filtrates or the absence of the factor as a result of the particular growth medium used for preparation of the challenge cells.

Results obtained using the rabbit as an animal model are not inconsistent with the idea that the mechanism of perfringens food poisoning may be that of an "infection," if indeed the term infection is used in the context indicated by Hobbs and Sutton (17). They state that "the term 'infection' does not necessarily imply the invasion of tissue with the corresponding host responses, but may also include the multiplication of the organisms within the intestinal canal without the invasion of tissue". Multiplication of the organisms in the intestine would allow elaboration of the toxic factor found to be active in the rabbit. That the toxic factor may be detected in a sporogenic medium but not in an asporogenic medium is consistent with the fact that sporulation seems to occur readily in the intestine. It is not known if production of the toxic factor is associated with sporulation or if failure to obtain the factor in an asporogenic medium results only from a nutritional imbalance.

PREVENTIVE MEASURES

Clostridium perfringens may be grouped into five different types, A, B, C (including the type previously designated as type F), D, and E, which are separated on the basis of their soluble antigens or toxins. Indications are that all strains of type A and some of the type C strains are potential food poisoning organisms (17).

The organism is widely distributed in nature. It may be found in the air, dust, soil, and waters. Also, it has been isolated from a great variety of foods, and is present in the intestinal contents of man and animals. Therefore, it aptly may be called a ubiquitous microorganism. The incidence of *C. perfringens* in American foods has been studied by several laboratories. Results of three of these studies are presented in Table 6. These data show the incidence of *C. perfringens* in various foods examined by Strong et al. in Wisconsin (32), by Hall and Angelotti in Ohio (12), and by Nakamura and Kelly in Montana (27).

The data of Strong et al. show an incidence of *C. perfringens* in commercial prepared frozen foods, raw fruits and vegetables, spices, and home prepared foods ranging from 1.8 to 5.0%. However, in the meat, poultry, and fish category the incidence was 16.4%. The later study by Hall and Angelotti shows a much higher incidence of the organism in meat and poultry, with up to 82% of the veal samples being positive. This higher incidence is a reflection of the

procedure used for detection of the organism. Strong et al. used a direct plating technique for enumeration, whereas Hall and Angelotti, as well as Nakamura and Kelly, used an enrichment technique and therefore obtained more positive samples. The data of Nakamura and Kelly show that various sauce and gravy mixes also are contaminated with *C. perfringens*. Some of the products tested required heating for less than 10 min. If such foods were allowed to cool and were left at room temperature for several hours before serving, they could become potential sources of food poisoning.

With the evident contamination of foods with *C. perfringens* and with the ubiquitous nature of the organism, it would be difficult if not impossible to rely on complete elimination of the organism from food as a control procedure. Since spores of some strains of the organisms are very heat resistant, it may be expected also that cooked food may contain surviving spores. Even heat sensitive spores of *C. perfringens* have been shown to survive the cooking process (39) and indeed, the heat sensitive strains are also responsible for food poisoning outbreaks (33). Therefore, it is impossible to heat all foods sufficiently to inactivate all *C. perfringens* spores without making the food organoleptically undesirable. Control lies in prevention of spore germination and/or multiplication of the vegetative cells. This also is true of foods that have become contaminated subsequent to cooking.

In general, to prevent perfringens food poisoning, foods should be either cooked and immediately eaten hot, or cooled rapidly and refrigerated within 1 to 1.5 hr until required. Partial cooking of meat on one day with subsequent reheating the next day should be avoided. If this is impossible, the food should be boiled or re-cooked thoroughly. A particular problem exists with large carcasses of poultry that during cooking may not reach an internal temperature sufficient for lethality of *C. perfringens*. Raw foods such as meat and poultry should be kept separate from cooked foods and special attention should be used to insure that different surfaces and equipment are used for processing these foods.

With the long holding periods often involved during the preparation and serving of foods in mass feeding establishments, it is not too surprising that such establishments and their patrons frequently become victimized by this organism. However, the problem of perfringens food poisoning may not reside only in the mass feeding establishment. In the past few years there has been a great increase in the availability of convenience foods on the American market. Many of these are pre-cooked and are either frozen, refrigerated, or are hot. In the hands of the consum-

er they may require only warming or a short cooking time before use. Another convenience food service is that of vended foods. These are now widely used in schools, colleges, hospitals, factories, and other places. Abuse of such foods, especially those containing meat or poultry products by either the producer or the consumer may result in an unexpected encounter with perfringens food poisoning.

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AN EVALUATION OF THE SALMONELLA PROBLEM: SUMMARY AND RECOMMENDATIONS

COMMITTEE ON *Salmonella*, NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL¹

Editor's Note: At the request of the U.S. Department of Agriculture and the Food and Drug Administration, the National Academy of Sciences, through a committee of the National Research Council, has examined the salmonella problem in the United States. The work of this committee lead to the publication of a 207-page report entitled, "An Evaluation of the Salmonella Problem." It is Publication 1683 and is available from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418. Many readers of this Journal are interested in the salmonella problem and hence the summary of the report and recommendations by the committee appear below. Publication of these sections is with the approval of the National Academy of Sciences.

SUMMARY THE DISEASE

Seriousness of the problem

Salmonellosis is one of the most important communicable disease problems in the United States today. There are an estimated 2,000,000 human cases annually. In addition to the pain and suffering it causes, this disease is responsible for substantial costs in the form of medical care, hospitalization, and lost income through absence from work. Salmonellosis also causes substantial losses to the livestock and poultry industries through death of young animals, decreased milk and egg production, costly testing and control programs, and reduced value of contaminated products. Finally, the food-processing industry spends huge sums for testing and control programs, for remodeling plants and equipment, and for recall of contaminated products that are inadvertently

placed on the market.

There is no way to measure accurately the total cost of salmonellosis to the American economy, but on the basis of a few known examples we consider the total cost to be at least \$300 million annually, and probably more. As primarily a food-borne disease, salmonellosis is a potential threat to every resident of the country. Its prevention and control require the attention of the entire food-production, food-processing, and food-service industries, public health workers, regulatory agencies, physicians, hospital employees, veterinarians, laboratory personnel, and hosts of others, including the consumer himself.

The causal organism

Salmonellosis is an infection caused by bacteria of the genus *Salmonella*. Their native habitat is the intestinal tract of animals, including man, but they are easily spread to other environments where they may survive and even multiply. When ingested by a susceptible host, the salmonellae can cause a variety of disease syndromes, or they may simply multiply without eliciting clinical signs of disease. Such "asymptomatic carriers" can spread the infectious agent just as effectively as an individual who is clinically ill.

The salmonellae can be divided into three groups on the basis of their host predilections:

1. *Primarily adapted to man.* This group includes *Salmonella typhi* and a few serotypes of *S. enteritidis* that are rarely found in animals other than man. Infections (e.g., typhoid and paratyphoid fevers) are characterized by a prolonged incubation period (10 to 20 days or more), generalized disease with bloodstream invasion (as opposed to acute enteritis), and a tendency to produce carriers and to become endemic. Public health measures have succeeded in bringing diseases caused by organisms of this group under control.

2. *Primarily adapted to particular animal hosts.* Included in this group are several important pathogens of domestic animals, such as *Salmonella cholerae-suis* and serotypes of *S. enteritidis*—Pullorum, Gallinarum, Dublin, Abortusequi, Abortusovis, and Typhisuis. These organisms can all cause gastroenteritis in man, although serotype Dublin and *S. cholerae-suis* are the most important in this respect. Infections by the latter may be quite severe, particu-

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larly in children.

3. *Unadapted*. This group includes some 1,300 distinct serotypes of *S. enteritidis* that seemingly attack man and other animals with equal facility and with no evident host preference. In man, the disease typically consists of gastroenteritis beginning 6 to 24 hours after ingestion of the organisms. Infection is localized in the intestine, and blood stream invasion is not uncommon. The usual vehicle is contaminated food. Although many hundreds of unadapted serotypes are known, 96 per cent of the cultures isolated from man and animals belong to only 55 serotypes.

The large number of antigenically distinct serotypes, and the ease with which mutants can be obtained experimentally, has led to the supposition in some quarters that the salmonellae possess an unusual degree of "genetic plasticity." There is no sound basis to conclude that these organisms undergo genetic change to any greater or lesser degree than other members of the Enterobacteriaceae, or for that matter, other groups of bacteria. The salmonellae exhibit the usual mechanisms of genetic recombination (e.g., transduction, phage conversion, conjugation), and they readily give rise to mutants, but there is no evidence that the disease-producing capacity or other fundamental characteristics of the mutant progeny are significantly different from those of the parent cells.

The observation that multiple drug resistance can be transferred to salmonellae from *Escherichia coli* and possibly other intestinal microorganisms has raised questions about the safety of feeding antibiotics to domestic animals for stimulation of growth. The potential hazard of this practice has been demonstrated by observations that (1) antibiotic therapy in hospitals has led to a greatly increased incidence of antibiotic resistance among salmonellae isolated from patients; and (2) prophylactic and therapeutic use of antibiotics to control disease in calves has led to an increased incidence of antibiotic-resistant salmonellae in England. Thus there is evidence that widespread use of antibiotics is, indeed, increasing the drug resistance of the salmonella population in selected environments.

Antibiotic resistance may have little importance in regard to salmonella gastroenteritis because these infections, when limited to the intestinal tract, are not usually responsive to antibiotics. Treatment of infections in other parts of the body (e.g., blood-stream, urinary tract) would be seriously complicated, however, if the causal organisms were resistant to antibiotics and other therapeutic agents.

How man becomes infected

Most salmonella infections begin in the intestinal

tract following ingestion of the causal organism. In recognized outbreaks the usual vehicle is contaminated food. However, in the far more common sporadic cases and family outbreaks the vehicle is rarely identified. Both in these and in many hospital-associated outbreaks, particularly in infant wards, there is convincing evidence of person-to-person or person-to-fomite-to-person transmission, thus emphasizing the importance of personal hygiene in salmonella control.

Owing to the high frequency of salmonella infections in domestic animals, foods of animal origin (e.g., egg, meat, and poultry products) are the ones most likely to carry the organisms. Fruits and vegetables are usually free of salmonellae unless they are produced or handled in a contaminated environment. Processed foods, though not often involved in outbreaks of salmonellosis, may carry the organisms if they contain a contaminated ingredient (such as contaminated dried eggs, dried milk, or coconut), if the processing treatment is inadequate, or if they become contaminated after processing.

Foods also may be contaminated by food handlers who are excreting salmonellae or by rats, mice, insects, and other vermin. Cross-contamination from raw material to finished food by hands, utensils, or work surfaces is another hazard both in the kitchen and in the processing plant.

Water is not a frequent vehicle of salmonellosis owing to the efficacy of modern water treatment processes. Untreated water supplies may be contaminated, and surface waters not uncommonly contain salmonellae. The likelihood is greatest, naturally, where human and animal wastes are found.

Pharmaceutical and enzyme preparations from animal organs represent a special problem. The raw materials are commonly contaminated with salmonellae, and the organisms may not be eliminated during processing since, in order to preserve the desired biological activity of the products, only relatively mild bactericidal treatment can be used.

Of the many routes by which man can acquire salmonellosis, special mention should be made of household pets, including dogs, cats, turtles, chicks, and ducklings. Many outbreaks, particularly among children, have been traced to these sources.

HOW MAN CAN BE PROTECTED

There are two ways to protect against infection: prevent exposure to the pathogen or immunize the host. Immunization against typhoid has long been practiced, but there is no evidence that immunization would have practical value against salmonella gastroenteritis. Therefore, current control procedures

are aimed at preventing exposure, i.e., keeping salmonellae away from the potential victim.

Better care and sanitation in the home, nursery, hospital, and food-service establishment would no doubt reduce the incidence of salmonellosis, but the problem can not be eliminated as long as our foods are contaminated with the organisms. Although it is unreasonable in the foreseeable future to expect eradication of salmonellosis, a great deal can be done to reduce the incidence of salmonellae in our food supply and thereby minimize the likelihood of infection. To do this, salmonellosis in domestic animals and contamination of foods during processing must be controlled, and salmonellae in raw products must be destroyed and their growth prevented by processing. Regulatory, surveillance, and educational procedures must be developed for and applied to the task, and new knowledge for use in salmonella control must be generated by research.

Control of salmonellosis in domestic animals

Animals acquire salmonellosis much as man does, via feed and water and by direct contact with contaminated materials or other animals. As is true for man, animal salmonellosis is most severe in the young, whereas mature animals are more likely to develop inapparent infections and to become asymptomatic carriers of the organisms. These animals offer the greatest potential hazard to public health because they are the ones most likely to enter the human food supply undetected.

Traditional animal husbandry practices allow ample opportunity for the spread of salmonellosis within flocks and herds, but certain modern innovations are likely to exacerbate the situation. For example, increased use of contaminated animal by-products to feed poultry and swine (e.g., meat and bone meal, fish meal, and poultry meal) exposes more animals to infection; and greater crowding of animals into feeding lots, broiler houses, and holding pens increases the likelihood of spread from one animal to another. No less significant is the long-standing practice of crowding animals together in vehicles during transportation and holding them in dirty pens while awaiting slaughter. Numerous studies have demonstrated the rapid spread of salmonellae under these circumstances.

To eradicate salmonellosis from domestic animals will require radical and very expensive changes in management practices all the way from breeding to slaughter; it is therefore unreasonable to expect complete elimination of all salmonella infections in the foreseeable future. However, a great deal of improvement could be made simply by adherence to well-known principles of disease control. For example, the following steps would go a long way toward

reducing the incidence of salmonellae in domestic animals:

1. Minimize salmonella-contaminated feeds, giving special attention to animal by-products used largely for feeding poultry and swine.
2. Convert the present pullorum and fowl typhoid control programs into eradication programs involving all chicken and turkey breeding flocks.
3. Develop salmonella-free breeding herds and flocks, and protect them against contamination from outside sources.
4. Provide clean water supplies and hold animals in sanitary buildings and pens.
5. Segregate clinically ill animals and withhold them from the market as long as they are excreting salmonellae.
6. Schedule shipment of animals to permit holding them on the farm as long as possible and at the slaughterhouse for as short a time as possible.
7. Transport animals to market in clean vehicles.
8. Hold animals at the slaughterhouse in clean pens or cages.

Control of contamination in food processing

Food processing takes many forms. It may range from simple blending and packaging of dry ingredients (e.g., cake mix) to a succession of processing steps including a bactericidal treatment (e.g., ready-to-eat cured meats). Each process must be examined in terms of the nature of the raw material and the treatment it receives during processing. In any event, the processor must ensure against the addition of salmonellae from the processing-plant environment. This precaution involves nothing more than adherence to time-honored principles of sanitation and good manufacturing practice.

Even with frequently contaminated foods (e.g., poultry and meats) the number of individual animals carrying salmonellae is usually relatively small. Unfortunately, however, many slaughtering procedures provide very effective means of spreading contamination from infected to clean carcasses. Correcting this problem will require substantial changes in slaughterhouse methods.

Similarly, a few contaminated eggs can contribute salmonellae to large quantities of clean eggs during blending for freezing or drying. Salmonella control thus depends on effective pasteurization of the liquid egg before further processing.

Most dry blending operations (e.g., gelatin desserts) do not include an effective bactericidal treatment; hence, control depends on the use of clean ingredients.

Whatever the process, care must be taken to avoid reintroduction of salmonellae by contaminated equipment or by airborne dust.

Destruction of salmonellae and prevention of growth

When a food product (e.g., poultry, eggs, meat) is naturally contaminated with salmonellae, the only protection for the consumer lies in a bactericidal treatment. With fresh meat and poultry this step takes place when the food is cooked for the consumer. With processed eggs, ready to eat meats, milk, and similar items it is done in the processing plant, usually by heat.

Fortunately, in most foods salmonellae are easily killed by heat. The effectiveness of a given heat treatment depends on several factors, including, especially, the available water, pH, and number of organisms to be killed. Therefore, any bactericidal treatment considered for a particular product must be evaluated in terms of the composition of the food. Products containing high concentrations of sugar, for example, require more rigorous treatment than products with little sugar.

Salmonellae should not be allowed to grow in a food product at any time. Large numbers of the organisms increase the likelihood that some will survive the bactericidal treatment, if one is used, and also the hazard to personnel working in the plant. Prevention of growth involves the application of well-established bacteriological principles concerning pH, available water, temperature, and similar factors.

Vigorous pursuit of the foregoing steps—i.e., reducing the incidence of salmonella infections in domestic animals and adherence to good manufacturing practices in food processing—should go far to ameliorate the salmonellosis problem but will not eliminate it entirely. The effectiveness of these steps can be measured only in terms of reduced incidence of salmonella-contaminated foods on the market and on reduced incidence of human salmonellosis as reported to the U. S. Public Health Service.

Inherent in any effective system for prevention of salmonellosis are the activities of three groups: the food-processing industry, regulatory agencies, and surveillance agencies.

Industry controls

Serious and widespread efforts to prevent the sale of salmonella-contaminated foods in this country have been in effect for less than three years and have been applied only to certain products in interstate commerce. Existing control measures were established by the Food and Drug Administration on the grounds that salmonella contamination constitutes adulteration. Meat and poultry products have not been subjected to the same degree of scrutiny.

The initial thrust of regulatory activities has been made at products known to be responsible for outbreaks of salmonellosis (e.g., processed eggs, nonfat dry milk, inactive dry yeast, carmine dye) and has

been expanded to products in which these materials serve as ingredients (e.g., noodles, candy, milk chocolate). Presence of salmonellae has been considered grounds for recall of the product from the market.

Of necessity, and perhaps properly, food processors have responded to regulatory pressure by vastly increasing their efforts to avoid salmonella contamination in their products. Large sums of money are being spent for testing raw materials and finished goods and for monitoring the environment of the processing plant. Coincidentally, the regulatory agencies, especially the FDA, have increased the scope of their testing programs for products on the market.

Whether the current monitoring programs of industry and the regulatory agencies have caused significant reduction in the incidence of human salmonellosis is unknown. There are ample reasons to believe that mishandling of foods in the home and in food-service establishments is far more significant in human salmonellosis than are processed foods such as candy or even dry milk.

We can not condone the sale of foods containing salmonellae, but at the same time we must recognize that salmonellae can be found in many products if a sufficient number of tests are made. Therefore, one may ask: When should we stop testing and conclude that a product is salmonella-free (which may simply mean that the contamination level is below the sensitivity of the test procedure)?

The lack of a definitive sampling and testing procedure has caused confusion and uncertainty in the food-processing industry. Basically, a food processor wants to know if a given lot of material is safe to ship. How much testing must he do before he can conclude that the product is neither a hazard to health nor likely to be seized by a regulatory agency?

No one knows the minimal infective dose of salmonellae. We know that it varies with serotype, strain, and host. It is safe to conclude that a single salmonella cell offers greatest hazard if it is in a product that will allow growth before consumption or in a product intended for the most susceptible consumers (e.g., infants, the aged, and the infirm).

Therefore, in assessing the potential salmonella hazard of a given product, we believe its ultimate use should be taken into consideration. Is the product likely to be consumed without cooking or other bactericidal treatment? Is there likely to be opportunity for growth before consumption? Is the product intended for individuals in the more susceptible segments of the population?

In Chapter 10, we have suggested a sampling and testing scheme that will, we believe, relieve much of

the uncertainty faced by food processors today and at the same time afford ample protection against distribution of processed foods containing significant levels of salmonellae. We are not recommending finite tolerances *per se*. Rather, on the basis of knowledge now available, we believe that salmonella levels too low to be detected by the proposed procedure entail relatively little health hazard to the consumer. For this proposal to be of value it obviously must be acceptable to both regulatory agencies and food processors.

There is no way to be absolutely sure that a given lot of food is salmonella-free in the absolute sense without testing every gram of it. Nevertheless, we believe the proposed sampling and testing plan will give ample protection.

Regulatory controls

Regulations do not prevent salmonellosis, but the incidence of the disease could be reduced significantly if suitable regulations were adopted and enforced. At the present time, many regulatory agencies are involved at different levels of government with varying degrees of effectiveness.

The Food and Drug Administration, with primary concern for the consumer's safety, enforces the provision of the Food, Drug, and Cosmetic Act that bans the distribution of adulterated foods in interstate commerce. Salmonella contamination to any detectable degree is regarded as adulteration. The agency has no jurisdiction over products that are manufactured and sold intrastate.

The U.S. Department of Agriculture is primarily concerned with the welfare of the farmer, but it is also responsible for supervising the slaughter and processing of meat and poultry. Animal-disease prevention is a major part of its activity, and the inspectional procedures at slaughterhouses are designed to prevent the use of diseased animals for human food. Yet these inspections do not include the detection of salmonellae on meat and poultry.

Some state agencies, usually the departments of agriculture or public health, inspect food-processing plants and enforce regulations covering safety and wholesomeness of foods produced within their jurisdictions. In general they tend to follow the procedures of the federal regulatory agencies (FDA and USDA), but practices vary widely from state to state. In addition, many state boards of health inspect restaurants, hotels, institutions, and other food-service establishments, although such inspection rarely includes measures that would be effective in preventing salmonellosis.

A very few large municipalities and some counties maintain inspection and laboratory facilities that function as described for state agencies. However,

most municipalities do little that is effective in prevention of salmonellosis.

As might be expected with so many different agencies involved, there are areas of overlap and areas with little or no supervision. Both the FDA and the USDA and some state agencies inspect egg-processing factories, milk-drying plants, and rendering establishments with particular attention to salmonella control. Yet no agency seemingly has given active attention to the presence of salmonella-contaminated meat and poultry products on the market.

Of probably even greater importance in the prevention of human salmonellosis is the woefully inadequate supervision of mass-feeding operations including caterers, restaurants, hotels, delicatessens, institutions, and schools. State and municipal inspectors, when available at all, seem to be more concerned with what they can see (e.g., hairnets on employees and window areas in kitchens) than with salmonellosis.

With the historical precedent of multiagency jurisdiction and the general reluctance of state officials to welcome federal intervention, we are hesitant to recommend that a single agency should be charged with control of salmonellosis throughout the country. At the very least, however, there should be closer coordination and exchange of information between the several federal agencies and between state and federal organizations to assure a minimum of overlapping of their activities and to eliminate gaps in regulatory coverage. In particular, and in view of the rapidly growing trend of Americans to eat away from home, we urge that closer attention be paid to salmonella control in mass-feeding establishments.

It is clear that none of the agencies is equipped to do all it should be doing toward salmonella control. The deficiency is most acute at the state and local levels where, in our view, the need is greatest.

Surveillance

Though not a control measure itself, surveillance is an essential adjunct to any control system designed to prevent or minimize salmonellosis. Surveillance is necessary to know the magnitude of the problem, to indicate areas where investigation is necessary, and to measure the effectiveness of corrective measures. The salmonella surveillance program of the United States, though admittedly inadequate, already has demonstrated the seriousness of the salmonella problem in public health. Moreover, by virtue of clever epidemiological work, it has revealed certain vehicles for salmonellae (e.g., nonfat dry milk) that were not previously suspected. Thus continual surveillance is necessary to provide warnings of potential hazards, to explain the sources of outbreaks, and to provide a measure of effectiveness of control procedures in-

stituted by industry and governmental agencies.

If all foodstuffs could be freed of contamination, if everyone drank and swam in potable water, and if all carriers could be cleared of salmonellae, human salmonellosis would virtually disappear. This ideal obviously is not in prospect, and man must learn to live with salmonellae for many years to come.

Education and training for prevention of salmonellosis

A great deal has already been done to focus the attention of the food-processing industry, and to some extent the food-service industry, on the seriousness of the salmonella problem. Effectiveness has been greatest where regulatory pressure was applied. However, the vast majority of the public and personnel of the various food-associated industries barely know that salmonellae exist. Many of them have suffered from salmonellosis, but they do not know why or how to avoid future incidents.

With salmonellae in the environment as they are now, significant progress in reducing the incidence of human salmonellosis will require a massive educational campaign directed at personnel of the food-processing, food-distribution, and food-service industries, farmers, and even housewives. Equally critical is the education of physicians and veterinarians to the importance of recognizing and reporting cases of salmonellosis and of hospital personnel in preventing the spread of salmonellae among patients.

In view of the many facets of the salmonella problem and the large numbers of people to be informed, we believe the federal government should institute a broad continuing program using all appropriate communications media to inform the public about ways to prevent salmonellosis.

Research

Finally, for the long-term effective control of salmonellosis, much remains to be learned about the biology of the organism, host susceptibility, epidemiology, and the application of control measures.

RECOMMENDATIONS

Insofar as practicable we have grouped our recommendations around the major problems that relate to prevention of salmonellosis: contamination of raw food products and drinking water; contamination of processed foods, feeds, and drugs; and mishandling of foods during preparation and serving.

Education is an essential part of all control programs, and for this reason we have assembled the recommendations for education and training in one group.

Finally, truly effective control of salmonellosis will

require information that is not now available; hence, our recommendations for research are in one group.

I. CONTAMINATION OF RAW ANIMAL PRODUCTS AND DRINKING WATER

(a) Steps should be taken toward universal participation in a salmonella-control program for poultry flocks and other livestock, concentrating on the prevalent serotypes first. Educational and regulatory programs are required to make this recommendation effective. Assistance should be given by education institutions and regulatory agencies to improve and implement better controls in husbandry practices, including feeding and management programs designed to eliminate or reduce salmonella infection or contamination in poultry flocks and in other livestock. Educational programs should stress the benefits to the producer that result from a salmonella control program.

(b) An eradication program should be developed for pullorum disease and fowl typhoid involving all chicken and turkey breeding flocks in the United States.

(c) Buildings and equipment for domestic animals should be designed and constructed so that they can be easily and thoroughly cleaned and sanitized.

(d) Regulations that require the reporting of animal infections due to *Salmonella* serotypes should be developed.

(e) The use of truly low levels of antibiotics in feeds for promotion of growth of animals should be permitted until and unless it is proved that these levels are not safe for the consumer and so long as genetic changes of the microbial organism occur at an acceptably low rate. The use of higher levels for prophylactic purposes should not be permitted. This recommendation is not intended to preclude therapeutic applications of drugs in the control of animal disease.

(f) Although salmonellae in raw food commodities such as shellfish, fruits, meats, and poultry are destroyed by adequate cooking or other sterilizing procedures, these foods are frequently not adequately cooked before consumption. They should be subjected to the same careful surveillance as now pertains to processed foods. It is therefore recommended that existing legislation concerning control be implemented, and, if inadequate, that study be initiated to develop adequate regulatory measures and to delegate responsibility for enforcing them.

(g) Community-drinking-water supplies should be chlorinated, if necessary, to ensure freedom from salmonellae.

2. CONTAMINATION OF PROCESSED FOODS, FEEDS, AND DRUGS

(a) Federal agencies should establish formal collaborative and cooperative agreements to fill gaps in control programs and to avoid duplication of effort, of regulations, and of inspections. Public health agencies should be included in these agreements.

(b) Similar formal agreements should be established between federal and state agencies, and among state agencies, to maintain uniformity of standards. Effective relationships should be established that will permit a strengthening of state responsibilities and authority and enable the development of effective working relationships with the food industries.

(c) Federal and state agencies should develop and implement programs to control salmonella contamination of feeds and feed ingredients. Federal and state laws should be comparable for administration of acceptable state and national programs. Regulations should define inspection responsibilities and interagency relationships. Examples of important considerations include terminal pasteurization of animal by-products, protection of animal feeds or feed ingredients from recontamination by rodents, birds, and other wild animals or insects, and provision of clean, sanitized carriers and prevention of common transportation with other products in trucks, railroad cars, or other common carriers.

(d) Universities, industries, and official agencies should cooperate in developing and implementing improved slaughtering practices and food-processing methods, with special attention to poultry and swine. The list of undesirable practices included in Chapter 8 illustrates areas where improvement is needed.

(e) More consultative and educational assistance should be provided to small industries by the states.

(f) Architectural design of processing plants should be developed to improve control of airborne contamination and cross-contamination of food and feeds during manufacture (e.g., elimination of U-shaped plant layouts).

(g) Practical quality-control guidelines should be developed for use by industry in establishing adequate quality-control practices. Such guidelines should be developed jointly by industry and regulatory agencies and should include recommendations for design and location of in-plant testing laboratories, uniform sampling procedures, and methods for testing foods and feeds.

(h) An attempt should be made to evolve a realistic assessment of the degree of hazard imposed by various foods, feeds, and drugs; and the quality-control requirements in relation to salmonella contamination should reflect the degree of hazard (see Chapter 10). Assessment of the potential hazard of

a given product should reflect not only past history but also current status as determined by continuing product surveillance. Appropriate provision should be made for addition of new products to the "sensitive" group as well as for the removal of products as justified by improved industrial practices.

(i) A definite policy should be stated regarding compliance or noncompliance. The term "salmonella-free" should not be used regarding salmonellae in relation to foods because it is not possible, with certainty, to assure complete absence. Limits of acceptability can be based only on the probability that salmonellae are not present or are present at less than a statistically defined level.

Sampling procedures should be clearly described and a "cut-off" established so that industry will have a reasonable base from which to determine if its products meet requirements.

(j) Federal regulatory agencies should provide information to industry explaining and justifying proposed regulations and inspection practices. Insofar as possible effort should be made to secure compliance by distributing notices of requirements to the affected industries well in advance of any punitive action. In general, regulations should be directed toward improving a food product rather than simply toward policing it.

(k) Government, diagnostic, and industry microbiology laboratories should work together to develop a plan for reference laboratory services. Government laboratories should develop competence where it is lacking and should provide consultation and training for industry and private consulting laboratories.

(l) A model ordinance or code should be developed for the licensure or certification of independent commercial laboratories concerned with salmonellosis, and states should adopt measures to assure the competence and reliability of these laboratories.

(m) Imported foods, feeds, and drugs should meet the same standards as those imposed on domestic products.

(n) Water used for washing foods and food-plant equipment should be chlorinated or otherwise treated, if necessary, to kill salmonellae.

3. MISHANDLING OF FOOD DURING PREPARATION AND SERVING

(a) There should be more frequent and more thorough inspections of restaurants, catering establishments, hotels, institutions, and other mass-feeding facilities. They should be made by persons who are trained in the area of food handling and facilities sanitation, and the goal should be to achieve a level

of performance in food-service operations equivalent to that required of food processing. Regulations necessary to achieve salmonella control should be enacted and enforced by the appropriate local or state agency.

(b) Agreements between federal and state agencies should be devised to provide for inspection of food-service establishments that are not now adequately controlled because of confusion of responsibilities. Such facilities as restaurants on interstate highways and certain others operated on federal property are examples.

4. EDUCATION AND TRAINING

Effective control of salmonellosis depends heavily on a continuing nationwide education and training program that will inform, motivate, and periodically retrain the multitude of individuals in nearly all walks of life, who must help to improve the level of environmental sanitation and personal hygiene.

An essential aspect of the education effort is to change the current passive attitude toward diarrheal diseases on the part of professional and nonprofessional workers, in order to get public acceptance of the inconvenience and cost associated with detection and control of salmonellosis. Active support by the medical, veterinary, and allied professions, industry and food-service management, and official federal, state, and local agencies is crucial to the success of the control of salmonellosis.

(a) The federal government should take the lead in developing a coordinated industry-professional-local-state-federal-government plan for the control of salmonellosis that will generate the technical and financial support for the expansion of education efforts on a continuing basis. To effect the plan, an official agency should be designated to coordinate operations, to develop and compile training aids, to serve as a clearinghouse for authentic information, and to evaluate and standardize training concepts. New teaching materials, such as programmed instruction courses, should be developed and used. The responsible agency should also devise mechanisms for greater sharing of information among industries and official agencies.

(b) The agency should receive assistance from an advisory committee representing appropriate professions, industries, and state and local agencies to review periodically the training materials and evaluate the effectiveness of the training effort throughout the nation.

(c) Government agencies should utilize existing private resources for training food-service personnel and should strengthen and support such resources.

(d) Federal, state, and local agencies should de-

velop more instructional and consultative competence among their personnel. There is increasing need to emphasize the educational and consultative approach to improvement of practices and thus to reduce the need for regulatory activities. Inspectors should be well trained in methods of inspection, industry practices and problems, and legal responsibilities. Industries should participate in the training to reflect the realities of the operations under consideration.

(e) More education should be directed toward the importance of personal hygiene and food-handling practices as well as environmental sanitation. Such education should be centered at universities and schools where food-service personnel are trained. Restaurant training programs should emphasize correct personal hygiene and food-handling procedures.

(f) The teaching professions at all levels should be encouraged to incorporate sound concepts of personal hygiene and environmental sanitation in the curriculum of primary, secondary, collegiate, trade, and professional schools.

(g) More emphasis should be placed on the education of medical students and physicians in epidemiology, including that of salmonellosis, and on the physician's role in prevention and control of this disease. This training should be included in the physician's postgraduate experience as well as in his formal medical education.

(h) Hospital administrators and infections-control committees should be especially alert to the threat of salmonellosis and should give increased attention to the prevention of hospital-acquired infections. Hospital personnel should be periodically trained in good personal hygiene and good handling practices to upgrade food service and sanitation practices in the hospital, particularly in infant wards.

(i) Colleges and universities should be encouraged to educate architects and engineers in the proper design and construction of hospitals and institutions with reference to disease control, spread of infectious agents, and food-handling facilities. The same kind of education is needed with reference to proper design of food-processing plants and food-service facilities.

(j) Health-oriented professional organizations should be encouraged to organize symposia, round-table discussions, and other types of programs intended to inform their members about control of salmonellosis.

(k) Training that emphasizes the importance of personal hygiene and good sanitary and food-handling practices should be required for top management in industry so that it, in turn, can provide such training for personnel.

(l) Industry and official agencies should urge food

advertisers to illustrate good sanitary practices in displays regarding foods and their preparation.

(m) Authors and publishers of cookbooks should be encouraged to include in their publications statements or rules concerning safe handling and methods of rendering food safe for use.

(n) Effective means should be devised for the education of adult audiences having diverse backgrounds and interests, including all involved professions (medical, veterinary, engineering, law, and architecture, for example), industrial workers, housewives, farmers, and others whose day-to-day cooperation is necessary for the control of salmonellosis.

(o) The public and particularly homemakers should be informed of the potential dangers from turtles, baby chicks, and other pets brought into the home.

5. RESEARCH

(a) Methods should be developed for evaluating the effectiveness of salmonella control measures. For example, it is important to know the effect of eliminating salmonellae from animal feed on the incidence of salmonella infections in man and domestic animals. Similar studies should be conducted to measure the effect of eliminating certain (or all) serotypes from poultry breeder flocks on the incidence of salmonella infections in man. Development and evaluation of control measures require a baseline showing the incidence of salmonellae, but it is not feasible to obtain this information for the entire population. Therefore, studies should be conducted on a continuing basis in selected geographic areas. The results can be used to evaluate the effectiveness of control measures and, by extrapolation, to give a better idea than we now have of the magnitude of the salmonella problem.

(b) Support and encouragement should be given to development of improved equipment for food processing to replace equipment so designed that it contributes to poor sanitation in the plant.

(c) Support and encouragement should be given to research on improved laboratory methods for recovery of salmonellae from foods and for the assessment of sanitation in food-processing plants. Special attention should be given to methods that are applicable for routine process controls.

(d) Studies should be conducted to increase understanding of the nature and occurrence of salmonella infections in man and animals, the modes of transmission, the relative pathogenicity of different serotypes, including strain differences, and to define more clearly the infective dose and factors that affect host susceptibility.

(e) Research should be encouraged to explore the

feasibility of immunization against salmonella infections other than typhoid fever.

(f) Studies should be conducted on ways by which raw products become contaminated and on how to protect them from contamination.

(g) Studies should be conducted to explore ways to control the presence of salmonellae in animals through improved husbandry, slaughtering, and processing practices.

(h) Studies should be conducted to define more clearly the source of salmonellae in such products as dried milk, candy, and other products not commonly regarded as sources of infection in man.

(i) Studies should be conducted to determine the influence of low levels of antibiotics in animal feed on the resistance of salmonellae to antibiotics and the effect such use of antibiotics has on salmonellosis in man.

(j) Studies should be conducted to devise techniques, comparable in effectiveness to pasteurization of milk for destruction of salmonellae in nonfluid products. Times and temperatures required to kill some of the more common salmonellae over a wide range of water activities should be determined.

(k) Heat resistance of *Salmonella* strains in model systems should be determined over wide pH ranges and employing various organic acids to adjust the pH.

(l) Incidence in naturally contaminated foods of *Salmonella* strains that possess heat tolerance similar to serotype Senftenberg strain 775W should be determined.

(m) Research should be conducted to arrive at practical solutions to problems of motivation and conscientious use of available information. Continuing reassessment of educational efforts will be necessary, because such a program can be effective in controlling salmonellosis only when its essentials are widely and consistently practiced.

6. OTHER

(a) Each state should develop or have available one good salmonella typing center for reference by all laboratories in the state. Such a center should be capable of providing all industrial, private diagnostic, and public laboratories in the state with comprehensive typing service for the major serotypes. In some situations, one typing center may serve as a regional laboratory for several states. In such cases, formal contractual arrangements should be established. These centers should provide serotype information for epidemiologic studies of cases of salmonellosis and for national and state surveillance programs.

(b) Mechanisms should be developed and implemented to shorten the time between the appearance

of the disease and its being reported to public health authorities.

(c) To improve salmonella surveillance within the United States, the individual states should be encouraged to develop more consistent reporting of all isolates, regardless of whether the isolation is performed in a hospital or public health or other governmental laboratory. All salmonellae isolated from man, animal, or other sources (foods or feeds, for example), whether identified as to serotype or not, should be reported to the appropriate local public health department, which should in turn routinely report to the state public health department.

(d) Increased efforts should be given to initiating investigations of salmonella episodes (selected single isolations, family outbreaks, epidemics) as soon as possible after onset. Assistance (epidemiologists, veterinarians, sanitarians, laboratory facilities and personnel, and the like) from local, state, and federal agencies needs to be publicized, and wherever not available, should be provided. The results of these investigations should be reported in detail to the appropriate local, state, and federal agencies.

7. IMPLEMENTATION

Salmonellosis is only one of several food-borne diseases of man, and improvement in the control of salmonellosis will result in improvement in the control of other such diseases. These recommendations *in toto* constitute an extensive and long-range approach to the control of salmonellosis in man and it is obvious that not all can be implemented immediately. Furthermore, some of them have greater po-

tential for the reduction of salmonellosis than do others.

It is therefore suggested that the recommendations be categorized and implemented in phases. The first category, we suggest, should include those recommendations that develop mechanisms for communication, collaboration, and cooperation among the various federal and state agencies and among the official agencies and industry [for example, Recommendations 2(a), (b), (c), (e), and (k) and 3(b)].

We suggest that the second category include those recommendations that are of major communication or promotional nature, especially those dealing with agency-industry communication and education and training [for example, Recommendations 2(h) and (i) and 4(a), (b), (d), (e), and (f)].

The third category includes those recommendations that have the greatest potential for removal of salmonella from the food chain [for example, Recommendations 1(a) and 3(a)].

During the first year of implementation, the first category [except Recommendation 2(c)] and Recommendations 2(h) and (i) of the second category should be completed, and Recommendations 4(a), (b), (d), (e), and (f) of the second category should be initiated.

During the second year, the recommendations of the third category should be initiated.

The remaining recommendations should be given priority ratings, placing emphasis on the promotional and educational recommendations, and implemented as quickly as feasible. Within five years, discernible progress on all recommendations should be evident if timely control of salmonellosis is to be achieved.

NEW YORK CITY'S RAT CONTROL PROGRAM

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ABSTRACT

This paper describes the rat prevention and control program presently conducted by the New York City Department of Health.

The legal basis for extermination activities in buildings and vacant lots is reviewed. Eradication measures in use by Bureau of Pest Control exterminators are elaborated upon. Community education techniques are explained as methods employed to secure the cooperation of tenants, property owners, and others living within urban areas. Block demonstrations, school assemblies, classes for welfare dependent mothers, neighborhood health fairs, and clean up programs are discussed as examples of educational approaches to upgrade sanitation levels. Mass media advertising approaches as educational tools to reach the grass roots in the community are explained.

A summary is given of the progress during the past 5 years of prevention and control activities. Evaluation of the program is afforded by citation of the incidence of reported rat bites prior to and since the inception of these abatement activities.

The methods used and the experience gained from the procedures discussed should prove valuable to environmental health officials engaged in rat control activities in other urban areas.

Several crusades and concerted drives to control rats have been organized and conducted within the City of New York during the past few decades. Unfortunately, as in so many other major cities where large numbers of persons reside in congested areas and where old slum-type conditions exist, these campaigns met with little or no success. Although the efforts were usually well meaning, all ran out of steam long before the rats ran out of food and shelter.

New York City's present rat control program in multiple dwellings and vacant lots has been in existence for 5 years. The budget allocated approximated one-half million dollars annually during the first 3 years. For the past two years supplemental state funding increased the allocated funds to 1.5 million dollars annually. Although this has been a small allotment for a rat control program in a city of 8 million people, nonetheless the results reveal some significant accomplishments.

Larger additional budgetary funds recently became available from the federal government. With the new federal funds expansion of present activities

is in process and greater gains may be realized. However, it should be borne in mind that this paper confines itself to the city's control program prior to the federal appropriation which became effective beginning July 1, 1969.

LEGAL BASIS FOR OPERATION

At a meeting of the City's Board of Health in January, 1964, a resolution (1) was adopted which declared rat infestation of homes "dangerous to life and health". The Board ordered landlords to effectively exterminate rats in their buildings; to provide for proper removal of garbage, refuse and waste material; and to install stoppages to prevent infestations by rats. When landlords fail to rid their buildings of rats, the Board authorizes the Department of Health to send in city-employed exterminators to eradicate the rats in order to protect the life and health of the people living in these infested buildings.

A similar type resolution (2), which declared rat-infested vacant lots "dangerous to life and health," was adopted in April, 1965. At this time the Board authorized the department to take action against recalcitrant owners of such lots and as a control procedure to treat the lots with rodenticides.

Passage of the first resolution enabled the Commissioner of Health to make rat extermination a direct service operation with the department. Adoption of the second resolution expanded the direct extermination activities to provide for control of infested vacant lots. The new approach gave the department a direct method of dealing with the troublesome rat problem.

Many landlords of infested buildings are difficult to locate and it is frequently almost impossible to compel them to treat their properties. Under the present plan, building inspectors and public health sanitarians are authorized to inspect buildings and lots. If active rat infestation is found the landlord is given 5 days to correct the condition. Failure of the landlord to comply results in certification of the building or lot as rat-infested. City exterminators then enter and treat the premises with rodenticides.

ERADICATION PROCEDURES

After certification, exterminators post the building and notify the tenants that the Department of Health will start rat baiting activities in their apartments. At the same time, the building superintendent is notified that the cellar will be baited.

Treatments of a rat-infested building or lot begin within 2 to 3 days of receipt of a report that it is certified as rat-infested. A second treatment follows 1 week later. A third treatment occurs 2 weeks after the second treatment. Thus, a building or lot receives 3 treatments in the first 3 weeks following certification. Thereafter, monthly treatments are made. Heavily infested buildings may require more frequent treatments.

The city has a large fleet of pest control trucks. Each truck is driven by a motor vehicle operator and provides exterminating materials for 3 or 4 teams of exterminators and community aides-in-training. Trucks are equipped with rodenticides, insecticides, bait stations, spray guns, deodorizing agents, tongs, gloves, paper bags, and cartons.

The exterminators and aides work in pairs during treatments of buildings and vacant lots. Working in teams affords the exterminators protection in coping with unforeseen or difficult situations and enables the exterminators to closely supervise and train the community aides.

Pairing has other advantages. Some buildings become vacated after a series of treatments has begun. Cellars are dark. Stairways and ceilings become dangerous. Organic matter accumulates. The building becomes a source of food and harborage for rats. Under conditions such as these it is important that extermination treatments continue unabated. The presence of a teammate gives a measure of safety to the exterminators and aides while they are working. Additionally, exterminators and aides in teams perform a more thorough check for evidence of rats and harborages, and render a more complete service treatment of an infested building or lot.

Although there is no incidence of plague nor other rat-borne disease which presently is known to be transmitted by rat ectoparasites in New York City, ectoparasite control preliminaries precede the actual rat extermination treatments. These preliminaries are effective precautionary steps and protect the exterminator from insect bites and infections.

Random samplings by combing captured live rats to determine the presence or absence of ectoparasites have been performed by the department's entomologist. In some of the samplings mites, lice and fleas, including *Xenopsylla cheopis*, the principal vector of plague, were identified.

Prior to entering a building exterminators spray

the uncovered parts of their bodies and their work clothes with the insect repellent, NN-diethyl-metaltoluamide. A 12 to 14% concentration is used and offers exceptionally good repellency for several hours. It is furnished to the exterminators in 5 oz spray cans, which are easy to carry and to apply.

If fleas or other biting insects are discovered in a cellar or apartment during the course of an inspection or extermination treatment the areas are treated with insecticides. Heavy infestations are treated with residual insecticides, such as Malathion or Baygon. These are applied from 2 or 3 gallon spray tanks. Light infestations are treated with formulated insecticides containing pyrethrins, piperonyl butoxide, and N-octyl bicycloheptene dicarboximide. The formulated insecticides are supplied to exterminators in 14 oz aerosol cans.

Because of their comparative safety the anti-coagulant type rodenticides, namely, warfarin, pival, diphacin, and fumarin are used to secure effective rat kills. These rodenticides are mixed with ground corn, whole corn kernels, oats, and oil. Sugar is sometimes incorporated within the baits as an attractant. As a safety measure a blue-green, a yellow-orange, or a pink-red color may be added to the rodenticides. To date this formulation has proved a readily acceptable and effective rat bait and no evidence of any resistance has been detected.

Receptacles for baits are marked with precautionary warnings, "Poison-Rat Bait-Do Not Handle" and are labelled with a New York City Department of Health identification mark.

In the treatment of open areas, such as lots or back yards, and in damp or flooded cellar areas, bait blocks are used. These contain anti-coagulant type rodenticides incorporated within a meat or fish base, to which corn or nut ingredients are added. All of these components are embedded in paraffin and molded into bait blocks which stand up better under exposure to adverse environmental conditions.

During the course of an extermination treatment, the apartments, hallways, cellars, yards, alleyways, and other public areas are thoroughly inspected for evidence of rat infestation. The exterminators place the anti-coagulant baits in bait stations at strategic locations such as rat holes, rat burrows, and rat runs. They are also placed behind and under refrigerators, stoves, sinks, and tubs. When the station cannot be hidden, it is protected by a barricade so that it is not readily accessible to youngsters and pets.

Thorough baiting is essential to secure effective kills. Rodenticides are in constant competition with garbage and other organic materials which serve as sources of foods for rats. The more bait made available

to the rat, the better the chances for its consumption and its eventual lethal effect.

Each bait station is filled with 7 to 8 oz of rodenticide. A minimum of 4 bait stations is put down in each apartment. Many bait stations, 4 to 6 ft apart, are placed in cellars. During the initial treatment of a large building it is not unusual for an exterminator to use as much as 40 lb of bait.

On revisits baits are examined for acceptance. Re-baiting of old stations and the addition of new bait stations is made according to need. If dead rats are found the carcasses are grasped by tongs, placed into a disposal container, and incinerated. If the exterminator detects any odor from a dead rat, which he cannot find, he deodorizes the area with a masking agent, such as paradichlorbenzene pellets or nuggets.

Extermination treatments of certified rat infested buildings or vacant lots by the Health Department are not free services. Landlords are charged at the rate of \$15 or \$20 per treatment depending on the number of building units treated. Charges for vacant lots are prorated according to the size of the lot. In addition to the charges for extermination services, landlords are subject to prosecution for violations of the Health and Housing Codes. Applications also are made to the City Rent and Rehabilitation Administration for reductions in rent for those tenants living in certified rat infested buildings.

Rent reductions have proven to be one of the most potent weapons available to the City to secure a remedying of the rat violations and compliance with the Health and Housing Codes. Experience in the past demonstrated that warnings were quite frequently ignored. Prosecutions, too, often resulted in only nominal fines. On the other hand, applications for rent reductions usually strike landlords where it hurts. In nearly all instances they are effective tools to force recalcitrant property owners to install rat stoppages, clean up buildings, and rid them of rats.

Treatments of rat infested buildings continue until re-inspections for decertification reveal removal of the conditions conducive to infestation. These re-inspections require the removal of rubbish, trash, and accumulated materials from the cellar, hallways, yard, and other public areas of buildings. Leaky plumbing throughout the building must be repaired. All holes and breaks, or other openings in floors, walls, and ceilings of apartments, cellars, hallways and other public areas of the building must be repaired, and there must be no evidence of rats in any part of the buildings. When all these conditions are met, the building is decertified if the landlord engages the services of a private exterminator whose qualifications have met the approval of the Health Department. City extermination then ceases.

The City Health Code (3) requires that persons engaged in the business of extermination to destroy or control rodents and other pests secure a permit issued by the Commissioner of Health. Permits are only issued to individuals who have successfully completed a course of training in extermination which has been approved by the department. If the business is a corporation or partnership, an officer or partner must successfully complete the approved training course. Furthermore, each employee of a permittee who carries on or supervises extermination operations must successfully complete an approved course of training. Both the employee and employer are issued individual qualifying certificates when they successfully complete their training courses.

The training courses to qualify exterminators are taught by public health sanitarians, educators, entomologists, and exterminators who have many years experience in rodent and insect prevention and control. They are conducted several times each year at local colleges and institutes, and in the Department of Health under the aegis of its Office of Professional Education. Written examinations are given at the conclusion of each training course.

The requirements relating to permits and qualifying certificates enable the Department of Health to restrict extermination activities to competent individuals who are trained in the prevention, control, and safety measures necessary to eradicate rats and other pests. When a building is cleaned up and the necessary rat stoppages are installed as requirements for decertification, the Health Code regulations of a permit and qualifying certificate afford reasonable assurance that the quality of extermination operations to be performed by a private exterminator will compare favorably to the quality of work previously performed by City exterminators.

COMMUNITY EDUCATION

The Health Department fully realizes that extermination alone cannot succeed without the active cooperation of tenants, property owners, and others in the community. The rat problem is an integral part of the problem of human behavior. The apathy of many individuals who live in the poverty stricken areas must be overcome. Barriers of indifference must be broken down. Tenants and landlords must be reached and taught to practice good housekeeping in apartments, in cellars, in public areas in and around buildings, and on vacant lots.

Tenants, building superintendents, and landlords sometimes are not aware of why they are plagued with rats. They don't understand how rats enter and harbor in their apartments and cellars. They often don't know how to keep their homes and environ-

ment clean. They must be shown and taught the importance of proper sanitation in the home, building, block, and neighborhood if the rat population is to be reduced. To remedy this the Health Department includes a comprehensive educational program in its prevention and control efforts. It aims to reach tenants, landlords, "supers," and youngsters, and to teach them the fundamentals of good housekeeping.

A Community Relations Unit was organized to identify with and reach the grass roots in the community. A supervising sanitarian and a senior public health educator are in charge of educational activities. Staff members are experienced sanitarians, exterminators, community organizers, and community aides skilled in the techniques of successful community relations. All work as a team to motivate members of the community to cooperate to keep their homes, buildings, and blocks clean. The entire staff plays an integral part in the program by blending its educational efforts with the eradication measures to combat the rat menace.

The Community Relations Unit arranges and participates in several types of educational activities aimed to reach individuals and groups in many areas. These include block demonstrations, school assemblies, welfare dependent training classes, neighborhood health fairs, and clean-ups of streets, backyards, and lots.

BLOCK DEMONSTRATIONS

The block demonstration is a unique educational tool designed to reach a maximum number of persons during a specified period. Demonstrations are held on selected blocks which contain a number of certified buildings. Block associations or other civic minded groups also may request them. They are scheduled for Saturday mornings when the chance of reaching the greatest number of residents is best.

Planning and careful preparations are essential to insure their success. The Community Relations Unit arranges for participation by the Sanitation, Fire, and Police Departments. Loudspeaker announcements are made and circulars are distributed which invite block residents to a briefing session which is held a few days before the demonstration.

A sanitarian or community organizer, who is in charge of a briefing meeting, alerts the residents to the necessity for and the importance of a rodent prevention and control program. If a local community group exists it is enlisted as a sponsor of the demonstration. Where no such organization exists the staff member in charge guides the group into forming a block association which will then sponsor the demonstration.

Teams consisting of a sanitarian, exterminator, fireman, community aide, and volunteers visit each apartment during the demonstration to instruct the tenants and building superintendents in the fundamentals of good housekeeping, food protection, methods of garbage storage and disposal, installation of rat stoppages, elimination of harborages, and prevention of fire hazards. Leaflets, which illustrate and explain many of these principles, are distributed to each family. Where necessary, leaflets in Spanish are used. In addition, interest and action by the community residents are stimulated by recording building or health violations and referring them to the jurisdictional city agency for investigation and corrective action where warranted.

Throughout the demonstration personnel in charge announce through loudspeakers the reasons and the objectives of the program. Fire and Sanitation Department personnel assist the Health Department by making announcements concerning safety, fire prevention, and sanitation. Taped music is broadcast to attract attention. Members of youth organizations, such as the Boy Scouts and church groups, sometimes participate with marching bands. This enlivens the program and stimulates interest. Community volunteers assist by distributing educational pamphlets. A rodent prevention and control display is set up on the block. Volunteers from the block are given Health Department volunteer badges as a means of identification. They retain the badges as a token of appreciation for their contributing efforts.

Each City agency which participates has a specific duty. The Police Department posts "No Parking" signs, barricades street entrances, reroutes traffic, and maintains order. The Sanitation Department sweeps and flushes the streets, collects garbage, and arranges for bulk pick-up of accumulated unused materials. The Fire Department inspects buildings and instructs tenants in fire prevention. All participating agencies blend their activities and coordinate their efforts to effect an integrated program for rodent prevention and control.

The Community Relations Unit organizes and participates in new demonstrations each week. Arrangements are made to continue the gains made by the demonstration by forming a block association to oversee the sanitation practices. Association members serve as "watch men" and leaders to keep the block clean. If problems arise the Community Relations Unit stands ready to assist.

Frequently the scheduling of briefing sessions and demonstrations spurs the formation of new associations and encourages block associations to combine and form neighborhood groups and community councils. These in turn expand their efforts and foster

other health and community action programs, create an awareness of community needs and develop a sense of civic pride and responsibility.

SCHOOL ASSEMBLIES

During its second year the Health Department expanded its educational efforts via school programs in public and parochial schools. These aim to instruct school age youngsters in rat prevention and control measures which they and their parents can institute.

Most schools in our City assemble weekly for special meetings. These assemblies are usually organized according to grade levels. Rodent control programs are presented for the upper grades of the elementary schools and junior high schools (sixth through ninth year grades.) The booking of programs is concentrated in the disadvantaged areas of the city.

Interest in the program is motivated by placing posters on rat prevention and control in the school prior to the assembly. The program emphasizes the diseases spread by rats, the causes and prevention of rat bites, the economic losses caused by infestations, and the methods school age youngsters and adults may use to help eliminate this pest. A motion picture is shown. Other program helps are displays of mounted stuffed rats, tightly covered metal garbage cans, and tightly covered jars and containers for proper storage of staple foodstuffs. A short lecture and discussion period, which gives the pupils an opportunity to ask questions, is included in the program. Illustrated leaflets for their parents are distributed to the children when they leave the assembly auditorium.

Certificates which are signed by the Commissioner of Health, and ribboned badges which identify school youngsters who volunteer as Junior Health Sanitarians, are issued to those who pledge to distribute rat prevention leaflets and answer questions from tenants in their own buildings.

Teachers who participate in the assembly submit evaluations and comments for review by the supervising sanitarian and health educator. These evaluations serve as a guide for improving future presentations. School principals, assistants, and teachers express the opinion that the assembly programs are educationally significant and most worthwhile.

Schools are receptive to this approach. Enthusiasm continues into the civics, science, and composition classes where lessons about the rat problem are conducted. Requests for program repeats are received each new school year. Enrollees as Junior Volunteer Health Sanitarians increase.

MASS-MEDIA ADVERTISING

During the past year the department had the courage and judgment to devise a mass-media advertising campaign as part of its rat prevention and control program. This advertising campaign utilizes the services of television, radio, newspapers, billboard posters, subway and bus car cards, leaflets, and buttons as tools to reach the grass roots community levels of the entire New York City population.

The department engaged the services and talents of a professional advertising agency on a non-profit basis to develop the mass-media tools. The supervisory staff rendered professional guidance throughout their development and gave final approval of the mass-media tools which evolved for this aspect of the program.

A slogan called "Starve A Rat Today," which stresses the importance of proper garbage containment, was created for the campaign. It aims to educate people to cut off the rat's main food supply and thus further reduce the City's rat population. This slogan was recently adopted as the official theme for the new federally funded abatement programs which are now becoming operational in the states of Pennsylvania, New York, and New Jersey.

The mass-media advertising campaign, which was developed as a public service by Geer Dubois and Co. Inc., in cooperation with the City Health Department, was recently named first among the ten best campaigns for 1968 by the magazine *Advertising Age*. Funds to produce and implement the campaign were made available to the City Health Department by the State Health Department as a part of a contractual agreement for expansion of the City's rat prevention and control program.

OTHER EDUCATIONAL APPROACHES

Other educational approaches are used in teaching rat prevention measures. Classes of welfare dependent mothers are organized in the neighborhoods where they reside. Class instruction consists of lectures, demonstrations, and discussions on rodent infestation, garbage storage and disposal, food protection, and principles of household sanitation. The use of audio-visual aids such as slides, motion pictures, stuffed rats, food containers, and garbage receptacles implements and stimulates interest in the sessions. The group members are given guidance in the solution of their individual sanitation problems. These sessions not only further the rat abatement program but also contribute to the attainment of a better understanding of other areas in environmental health.

The department participates with other City agen-

cies in backyard, alleyway, and lot clean-ups. Pest Control assigns educators, sanitarians, exterminators, and community aides as leaders in these activities. They exhibit displays and demonstrate the proper procedures in rat prevention and control. They distribute educational leaflets. They announce via loudspeakers the importance of good housekeeping and block cleanliness. During the clean-ups community aides, employed by the department, assist the Sanitation Department in clearing waste, rubbish, and debris from alleyways, yards, and lots. Exterminators bait rat infested areas before and after cleanups. The clean-up demonstrations are conducted by community aides under the supervision of environmental health professionals.

PROGRESS(4)

The year 1969 marks 5 years of activity since the inception of the City's rat extermination, stoppage, community education, and clean-up program.

During this period the department performed extermination treatments in 10,000 certified rat-infested buildings and vacant lots. More than 60% of them were decertified. This means that after extermination treatments by the department the negligent owners cleaned their property, installed the required rat stoppages, and made those repairs necessary to eliminate conditions conducive to rat infestation. On reinspection its sanitarians found these buildings and lots free of rats.

Significantly, more than three times as many building owners became apprehensive that their buildings would be certified and rent reduction proceedings would be instituted against them. Landlords of these buildings removed violations, contracted for private exterminators to rid their buildings of rats, and repaired and cleaned them. In this manner voluntary compliance was secured in an additional 30,000 buildings.

More than 700 buildings, which are being vacated prior to demolition in Urban Renewal Sites, were treated at the request of the City's Department of Real Estate. In addition, a large number of other rat-infested buildings and critical areas were treated at the request of other City departments.

The department's educational efforts were increased markedly during the past year. Whereas only 25 block demonstrations were held in the initial year of operations, 250 were conducted in 1968. Many thousands of people, living in the worst rat infested areas of the city, were instructed in sanitary housekeeping practices, proper garbage storage and disposal methods, and rat bite prevention.

During the course of these demonstrations several hundred new block associations were organized or

reactivated. The associations now represent and guide the residents of the block in coping with the rat problem and other community problems. They offer one of the best means of securing lasting improvements on the block as the department directs its efforts in prevention and control to new locations.

Through August, 1969 the department presented 411 school assembly programs attended by more than 135,000 pupils. It enrolled 9,500 school children as Junior Volunteer Health Sanitarians. These young volunteers, in turn, reached 194,000 tenants in the most aggravated and depressed ghetto areas of our city. The department has already scheduled 250 programs for the new school year. These requests increase as the school term progresses.

It is much too early to judge the "long term" value of the various educational and community participation programs initiated by the department. While better housekeeping practices and block improvements are visible in numerous segments within the sub-standard areas of the city little progress is observed in other segments. Hopefully, additional "long-term" upgrading of the sanitation levels within the homes and on the blocks will result as the program continues to gain greater support and cooperation from the people in the community.

From 1960 through 1963 the total of reported alleged rat bites in New York City, comprised of confirmed and non-confirmed cases, averaged 693 cases per year. In 1963 a total of 684 cases was reported.

The Department of Health of the City of New York started this program in early 1964. In that first year, with less than 10 months of operation in the extermination and educational aspects of the program, 599 alleged rat bites, a decline of 12.4%, were reported. The year 1965 showed a further decline to 497 cases, a 17.0% drop from 1964.

In the year 1966, the number of alleged rat bites reported was 562, an increase of 13.1% above 1965. This increase may have resulted from a loss of sanitarians and the transfer of the inspectorial function to another City department. As a result of the transfer, the number of inspections and certifications was significantly decreased. This pointed up the need for public health oriented sanitarians to perform certification inspections.

In 1967 environmental health sanitarians were once again pressed into certification work. Inspections, educational approaches, exterminations, and clean-ups were expanded. Further reductions in reported rat bites became evident. A decline to 430 rat bites was reported that year, a 23.5% reduction from 1966. Total reported rat bites showed a further decline in 1968 when 390 cases were recorded, a drop of 9.3% from the previous year.

Additional budgetary appropriations were recently allocated by the federal government and the state to widen the scope of operations. Further expansion of the program will soon become operational. This new funding will enable the department to augment its forces and further enlarge its inspection, eradication, clean-up, and educational efforts. A demonstration project in stoppage installations is planned to supplement the installation of stoppages presently required of recalcitrant landlords.

These concerted efforts by the department, with utilization of its professional and sub-professional staff and employment of additional aides from the

community, hopefully, will show a further reduction in rat bite cases and improvement in the sanitation levels within many of the critically depressed areas of our City.

REFERENCES

1. Resolution, Board of Health of the Department of Health, January 21, 1964.
2. Resolution, Board of Health of the Department of Health, March 19, 1965.
3. Amendment to the New York City Health Code, Section 171.15, February 8, 1966.
4. Intra-departmental Reports, New York City Department of Health, 1964-1969.

A STABLE MILK-LIKE EMULSION FOR MILKO-TESTER CHECK PURPOSES¹

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ABSTRACT

The preparation of a milk-simulating emulsion is described. Twelve such emulsions were investigated using the data of fat content determinations with a milko-tester automatic as criteria of stability. Low-fat emulsions of 1 and 2% were extremely stable after 147 days of storage at room temperature. Emulsions containing around 4 and 5% milk fat showed slightly varying fat contents during the latter part (35 days) of the 147-day storage period. Standard emulsions of this sort may find application in the calibration and checking of milko-testers, an instrument which has been gaining rapid and wide acceptance by persons engaged in milk fat content determinations.

With the introduction of the milko-tester (A/S N. Foss Electric, Hillerod, Denmark) for the rapid determination of fat in milk, the need has arisen for a convenient calibration, standardization, or checking procedure for this instrument.

At present the accuracy of the milko-tester is verified by simultaneously determining the fat percentage of several milk samples by one or more of the traditional methods (Babcock, Gerber, Roese-Gottlieb). Normally that method is chosen which the milko-tester is to replace. However, these older methods are too elaborate and time-consuming, e. g., about 20 min (Babcock) versus 30 sec (milko-tester), if one sample is considered. Furthermore, it may be

desirable to check the milko-tester several times a day. Only a rapid and accurate method, for obvious reasons, would be the logical choice.

This paper describes the preparation of an emulsion which may be used with the milko-tester. The liquid is extremely stable. It may be used again and again to show its "built-in" fat percentage.

PREPARATION OF EMULSION

Formulation.

Ingredient A—15.2 g sodium hydroxide was dissolved in 20 l distilled water. Ingredient B—20 ml of Atmos 300 (Atlas Chemical Industries, Wilmington, Delaware), a non-ionic surface-active agent, was dissolved in 1.45 kg liquefied anhydrous milk fat.

Blending and homogenization.

Ingredients A (room temperature) and B (50 C) were drawn from two separate funnels and homogenized at 2000 psig (first stage) and 500 psig (second stage). Since some butteroil was not incorporated, the resulting emulsion was rehomogenized immediately after the first treatment. A can was completely filled and traces of nonincorporated fat were removed from the top. No oiling-off was observed in the emulsion for at least five months.

Standardization.

The stock emulsion had a relatively high fat content. It was intended to be used in the preparation of standard emulsions with lower fat percentages. Dilutions were carried out by simply adding calculated amounts of ingredient A. Three standardized dilutions plus the original high-fat emulsion were kept for further testing.

Storage of standard emulsions.

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All emulsions were kept in 125-ml flasks, filled about one-half, which were covered with aluminum foil. Storage was at room temperature.

EVALUATION OF EMULSIONS AND RESULTS

After a storage period of 112 days, the emulsions were examined with a milko-tester automatic (MTA) 15 times during the subsequent 35 days. Three series each containing four samples of the emulsion were tested. The four samples ranged from low-fat to high-fat, i. e., they had fat contents ranging from 1 to 5.5%. Although the respective three series of four samples each were obtained from identical stock containers, they could not exactly be considered triplicates, since they were removed at different times under different conditions. Consequently, there was a slight variation in fat content.

Each individual sample was tested by the MTA after two rinse cycles. This was done to eliminate the fat carry-over effect which had been previously observed. The fat percentage read-out for a low-fat sample may be increased by 0.01 to 0.03 if preceded directly by a high-fat sample.

Table 1 shows the fat percentages of these samples. There was some day-to-day variation for all emulsions. With increasing age there was a slight increase in fat content, especially in the high-fat samples, probably resulting from a loss of moisture. In the high-fat samples a greater variation in fat content was observed than in the low-fat samples, as can also be seen by their standard deviations. A similar variation was observed with low-fat, medium-

fat, and high-fat samples of mixed preserved raw milk from several cows when examined six times over a period of 10 days. It could be argued that it is extremely difficult to draw representative samples from an emulsion; or that representativeness could only be questioned when ingredient percentages (fat in this instance) are examined in concentrations expressed to three significant figures.

It should be emphasized at this point that the MTA draws its sample to be analyzed from the sample container placed under its movable intake pipette. As a result, milk samples may be drawn repeatedly from the same source. The MTA requires about 1 ml for each analysis. In these experiments, each emulsion or milk sample remained in its original container which was merely placed under the instrument's intake pipette for the periodic withdrawals.

The important point, therefore, is the following: Had an emulsion sample deteriorated by deemulsification, then it would have been certain that unrepresentative amounts would have entered the milko-tester. Since sample withdrawal was repeated over a period of 35 days, such a change in stability would have been magnified and made visible by widely varying and/or gradually changing fat percentages.

Since this was not true after 147 days of storage and testing, the emulsion can be claimed to be stable for at least this period. The actual extent of its stability is still under investigation. However, it must be admitted that with high-fat emulsions there

TABLE 1. FAT PERCENTAGES OF EMULSION SAMPLES STORED FOR SEVERAL MONTHS. THREE SERIES (A, B, AND C) WITH FOUR SAMPLES EACH WERE EXAMINED REPETITIVELY FOR 35 DAYS WITH A MILKO-TESTER AUTOMATIC.

Age in days	A				B				C			
	1	2	3	4	1	2	3	4	1	2	3	4
112	5.55	4.28	2.07	1.06	5.43	4.36	2.13	1.06	5.48	4.33	2.19	1.05
113	5.41	4.20	2.06	1.07	5.28	4.31	2.12	1.06	5.40	4.35	2.22	1.05
114	5.44	4.21	2.06	1.06	5.27	4.27	2.11	1.05	5.35	4.33	2.20	1.05
116	5.45	4.24	2.08	1.07	5.28	4.33	2.13	1.06	5.37	4.35	2.21	1.06
117	5.38	4.14	2.04	1.05	5.18	4.32	2.10	1.04	5.26	4.28	2.18	1.05
119	5.50	4.28	2.10	1.08	5.28	4.32	2.13	1.06	5.37	4.31	2.24	1.07
120	5.46	4.20	2.08	1.07	5.24	4.30	2.13	1.06	5.37	4.36	2.22	1.07
131	5.56	4.29	2.11	1.09	5.32	4.37	2.17	1.07	5.58	4.45	2.24	1.08
132	5.50	4.21	2.11	1.09	5.30	4.35	2.16	1.07	5.57	4.42	2.23	1.08
138	5.54	4.25	2.13	1.10	5.37	4.40	2.17	1.07	5.73	4.48	2.26	1.09
139	5.52	4.21	2.11	1.10	5.35	4.40	2.17	1.09	5.74	4.50	2.26	1.10
140	5.59	4.25	2.12	1.10	5.36	4.41	2.17	1.08	5.73	4.53	2.27	1.09
141	5.50	4.20	2.11	1.09	5.38	4.40	2.18	1.07	5.70	4.49	2.26	1.09
145	5.58	4.21	2.13	1.10	5.43	4.45	2.19	1.09	5.80	4.53	2.27	1.10
147	5.52	4.19	2.10	1.08	5.41	4.40	2.18	1.07	5.53	4.55	2.26	1.10
Average	5.50	4.22	2.09	1.08	5.33	4.36	2.15	1.07	5.53	4.42	2.23	1.08
Std. dev.	0.062	0.041	0.028	0.017	0.073	0.050	0.028	0.014	0.175	0.092	0.030	0.020

is slightly less stability than with low-fat emulsions. Better care and protection from evaporation of the emulsion may improve this weakness. Throughout this study the emulsion samples received no agitation beyond the manual mixing action in a flask prior to analysis.

Other methods of checking milko-testers.

Since the major use of the emulsion described above would lie with milko-tester checking purposes and it would be used as a substitute for milk, milk itself was investigated as a possible standard. An hour-to-hour and a day-to-day check can easily be made with any kind of milk sample. However, deterioration will come about in a relatively short time.

Mixed preserved raw milk from several cows was tested with the MTA over a period of 10 days. Three milk samples with different fat levels, low, medium, and high, were examined. The milk was kept at room temperature. One drawback was the rather vigorous mixing of the samples required to reincorporate the cream layer every day. After 10 days, flakes became visible in the high-fat sample and testing was discontinued. After 15 days, the samples also began chemical decomposition, as evidenced by the change in the color of the preservative (potassium dichromate). It is this deemulsification (churning) and eventual decomposition which make milk

TABLE 2. REPETITIVE FAT PERCENTAGES OBTAINED WITH A MILKO-TESTER AUTOMATIC OF ONE HOMOGENIZED MILK (H) AND THREE DIFFERENT MIXED PRESERVED RAW MILK SAMPLES (R1, R2, R3) (AVERAGE VALUES).

Age of sample (days)	H	R1	R2	R3
2	3.38	—	—	—
3	3.78	2.72	3.80	5.39
4	—	2.68	3.79	5.33
6	—	2.71	3.77	5.31
7	—	2.66	3.76	5.30
9	3.74	2.71	3.76	5.29
10	3.76	2.71	3.77	5.32
11	3.83	—	—	—
12	3.83	—	—	—
16	3.79	—	—	—
17	3.79	—	—	—
18	3.74	—	—	—
19	3.75	—	—	—

unsuitable as a standard emulsion over an extended period.

Homogenized milk also was examined. Although this milk was considered spoiled after the fifteenth day, the fat emulsion—as reflected by the relatively constant fat percentage—was remarkably stable. Since decomposed milk samples have been shown to cause

problems with the MTA, and more so with the manual MK-II milko-tester, raw or homogenized milk could be used as a standard no longer than about 20 days, despite refrigeration or chemical preservation. Table 2 shows the results obtained with homogenized milk and with the raw milk samples indicating their suitability for checking purposes over this period. Most users of milko-testers are presently resorting to this practice.

A similar test solution based on milk is being developed by the Danish Dairy Research Institute (1969, *personal communication*). It is called Milko Gel and is prepared from the mixed milk of a large number of cows. After pasteurization and addition of gelatin and preservative, the product is packaged in sample bottles. The major advantage of Milko Gel over this emulsion is that it is unhomogenized. It will therefore respond better to defects in the homogenizer of the milko-tester.

Dry whole milk powder and four different instant nondairy coffee whiteners were briefly investigated as suitable standards which could be obtained by periodic reconstitution into a fluid of known fat content. Objection to these standards was threefold: First, operators of milko-testers, often with little or no technical education and trained to perform a routine procedure, cannot be expected to carry out critical gravimetric measurements and reconstitutions. Second, these dry substances are hygroscopic and will change weight on standing and atmospheric exposure, so that standard liquid emulsions made from them will gradually become unrepresentative of the original batch. Also, dry milk may cause problems in reconstitution resulting in non-duplication of fat contents from one time to the next. Instant coffee whiteners can be easily liquefied. However, considerable drift in the microammeter needle was observed on testing with an MK II milko-tester, so that an exact reading of the fat percentage could not be taken. Also disturbing was the fact that the milko-tester fat read-out, a function of presence of globules, does not agree at all (30 to 50% lower) with the fat percentage obtained by either the Gerber or Babcock method.

These preliminary experiments with this emulsion look so promising that it may well be chosen as a likely candidate for milko-tester checking purposes. More work on this subject is necessary and will undoubtedly be forthcoming, since rapid determination of fat in milk by milko-testers is becoming increasingly accepted around the world.

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THERMODESTRUCTION OF *BACILLUS* SPORES IN MILK¹

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ABSTRACT

The rate of heat destruction of spores of 12 selected strains of *Bacillus* species was determined in skim milk. *Bacillus cereus* and *Bacillus licheniformis*, the most prevalent *Bacillus* species in raw milk, were most heat resistant. The D values at 100 C ranged from 0.875 min for *Bacillus pumilus* to 4.10 min for *B. licheniformis* A-5. Extremes for Z values were 6.4 C for *B. licheniformis* A-1 and 11.5 C for *Bacillus circulans*. For each of the spores studied, linear regression equations with standard error are presented for the thermal destruction process at 95, 97.5, and 100 C. Heat resistance of bacillus spores in milk varied between the strains studied and the heating conditions imposed.

In previous work in the Department (5), a number of species and strains of bacillus sporeforming organisms were isolated from raw milk and characterized. In one phase of the study (4), results were obtained on the heat destruction of certain of these sporeforming organisms under semi-commercial conditions where complete elimination of other organisms was not achieved. Consequently, it was deemed desirable to conduct a heat-destruction study of these same organisms under laboratory-controlled conditions where a sterile medium was used. This study permitted the determination of the D and Z values for the spores of many of the isolates studied. Results are presented in this paper. A comprehensive review of other work conducted on sporeforming microorganisms in milk is given by Jayne-Williams and Franklin (2, 3).

METHODS

Organisms

Spores of the following *Bacillus* species were studied: *B. licheniformis* A-1, A-5, and ATCC 10716, *B. cereus* 1 and 7, *B. pumilus*, *B. cereus* var. *mycoides*, *B. coagulans* ATCC 7050, *B. laterosporus*, *B. circulans*, *B. megaterium* 9, and *B. spaericus*. With the exception of *B. licheniformis* ATCC 10716, *B. coagulans* ATCC 7050, and *B. megaterium* 9, the organisms were isolated from raw milk supplies by Martin et al. (5).

Spore preparation

Depending upon the particular species, one of three solid sporulation media was used: (a) nutrient agar containing 1.0% soluble starch and 0.01% manganese sulfate, (b) TAM agar

(Difco, 0892), or (c) sporulation agar (Difco, 0582).

The inoculated agar was incubated for period of 5-12 days at 35 C. Spores were washed from the surface of the agar with sterile 0.01 M phosphate buffer (pH 6.8) and concentrated from the wash mixture by low speed centrifugation. The supernatant was discarded and the pellet remaining was resuspended in buffer and recentrifuged. The washing and centrifugation steps were repeated for a total of six times. The final suspension in phosphate buffer was stored at 4 C. Just prior to the determination of heat resistance, spore suspensions were heated at 80 C for 12 min, cooled in ice water, and the spores concentrated at 1200 g for 10 min. The pellet was washed with buffer and recentrifuged three times, and then the sedimented spores resuspended in buffer. The suspension was adjusted spectrophotometrically to a spore concentration of approximately 10⁸/ml. This procedure yielded clean refractile spores as evidenced by microscopic examination.

Determination of thermal resistance

The rate of heat destruction of the spores was determined in reconstituted skim milk powder (9% total solids) by the procedure of Stumbo (8). The skim milk was sterilized at 121 C for 10 min. Cold, sterile skim milk, constantly agitated by a magnetic stirrer, was inoculated with the spore preparation to a level of 10⁵-10⁶ spores/ml, and 2-ml aliquots were distributed into sterile ampoules and the ampoules were heat sealed. One ampoule was opened immediately and the spore population determined by plating on Plate Count agar (Difco, 0479) with 0.1% added soluble starch. Plates were incubated for 24 or 48 hrs at 35 C, depending upon the species being studied. The remaining ampoules were submerged completely in a thermostatically-controlled mineral oil bath. When the contents of the ampoules had attained the desired temperature and at experimentally selected time intervals thereafter, three ampoules were withdrawn, cooled rapidly in ice water, and the contents were analyzed for surviving spores by the agar plate method. A Model 42, YSI Thermistor with a thermistor probe having a time constant of 0.75 sec was used to monitor the temperatures of the skim milk contained in the ampoules.

Mathematical treatment of data

For computation purposes, zero time was taken as the time the contents of the ampoules had attained the desired temperature.

Results obtained were subjected to statistical analysis (7). The best fit straight lines for the plots of heating time versus log of surviving spores were determined by the use of the linear regression equation,

$$Y = bx + a \pm S.E.,$$

in which Y is the calculated log number of surviving spores at heating time x, b is the slope of the heat destruction curve, a is the difference between the mean of the log survivors and the product of the mean time interval and the slope, and S. E. is the standard error of estimate.

¹Article 2:69. Department of Dairy Technology. This investigation was supported by Public Health Services Grant FD-00072 from the Office of Research and Training Grants, Food and Drug Administration.

TABLE 1. LINEAR REGRESSION EQUATIONS (\hat{Y}) WITH STANDARD ERROR OF ESTIMATE (S.E.) FOR THE THERMODESTRUCTION OF *Bacillus* SPORES IN SKIMMILK

Organism	Heating temperature (C)					
	95		97.5		100	
	$\hat{Y} =$	S.E.	$\hat{Y} =$	S.E.	$\hat{Y} =$	S.E.
<i>B. licheniformis</i> A-1	-0.0564X + 5.510	± 0.070	-0.1545X + 5.646	± 0.050	-0.3540X + 5.180	± 0.060
<i>B. licheniformis</i> A-5	-0.0480X + 6.118	± 0.185	-0.1663X + 5.763	± 0.192	-0.2377X + 5.004	± 0.056
<i>B. licheniformis</i> ATCC 10716	-0.0861X + 5.574	± 0.252	-0.1660X + 5.428	± 0.193	-0.3560X + 5.414	± 0.142
<i>B. cereus</i> 1	-0.0983X + 5.600	± 0.160	-0.1556X + 5.324	± 0.125	-0.3220X + 5.240	± 0.070
<i>B. cereus</i> 7	-0.0696X + 5.142	± 0.232	-0.1260X + 5.066	± 0.158	-0.3720X + 5.155	± 0.216
<i>B. pumilus</i>	-0.2470X + 5.095	± 0.279	-0.6060X + 5.050	± 0.210	-1.1400X + 3.900	± 0.204
<i>B. cereus</i> var. <i>mycoides</i>	-0.0957X + 5.480	± 0.252	-0.1853X + 6.217	± 0.266	-0.4040X + 6.090	± 0.131
<i>B. coagulans</i> ATCC 7050	-0.1407X + 5.373	± 0.063	-0.2860X + 5.646	± 0.125	-0.5010X + 4.979	± 0.148
<i>B. laterosporus</i>	-0.1720X + 6.099	± 0.169	-0.3180X + 5.902	± 0.204	-0.8480X + 5.249	± 0.139
<i>B. circulans</i>	-0.2147X + 5.730	± 0.171	-0.3666X + 5.250	± 0.222	-0.6180X + 4.325	± 0.241
<i>B. megaterium</i>	-0.1544X + 5.340	± 0.148	-0.3660X + 5.333	± 0.231	-0.4210X + 4.068	± 0.376
<i>B. sphaericus</i>	-0.1332X + 6.108	± 0.145	-0.2570X + 5.922	± 0.183	-0.4520X + 5.349	± 0.235

The D and Z values were obtained from the heat destruction curves as suggested by Collins and Dunkley (1).

RESULTS

Linear regression equations and standard error of estimate for the thermal destruction of the spores of the twelve organisms studied at 95, 97.5, and 100 C in skimmilk are presented in Table 1. For all of the organisms, the rate of spore thermodestruction was essentially linear with a progressive decrease in numbers with each increment increase in holding time.

Thermal destruction curves in milk held at 100 C are presented (Fig. 1) for spores of *B. cereus* 1 and 7, *B. licheniformis* A-1, and *B. pumilus* because of the preponderance of *B. cereus* and *B. licheniformis* in raw milk supplies and, because *B. pumilus*, is highly heat labile. Differences in the heat resistant properties of the five organisms in the spore state are revealed: *B. cereus* 1 was the most heat resistant, *B. cereus* 7 and *B. licheniformis* A-1 exhibited intermediate heat resistance, and *B. pumilus* was decidedly heat labile.

The D values, an expression of the time (min) required for the heat destruction of one log cycle of spores, for the bacillus spores studied varied widely and decreased as the temperature was increased (Table 2). At 95 C, the D values ranged from 4.03 min for *B. pumilus* to 20.5 min for *B. licheniformis* A-5. At 97.5 C, *B. pumilus* was the least heat resistant and *B. cereus* 7 the most, whereas, at 100 C, *B. licheniformis* A-5 exhibited the greatest heat resistance. The average D value for the 12 spores studied was 10.13, 4.66, and 2.36 at 95, 97.5, and 100 C, respectively.

Between individual strains of a particular species, variability was noted in the D values at the different

TABLE 2. THERMORESISTANCE OF *Bacillus* SPORES IN A SKIMMILK MEDIUM

Organism	Heating temperature (C)			
	95	97.5	100	Z value
	---D value (min)--- (C)			
<i>B. licheniformis</i> A-1	17.76	6.40	2.85	6.4
<i>B. licheniformis</i> A-5	20.50	6.00	4.10	6.8
<i>B. licheniformis</i> ATCC 10716	12.10	6.00	2.87	7.8
<i>B. cereus</i> 1	10.16	6.45	3.10	9.6
<i>B. cereus</i> 7	14.40	7.90	2.70	7.1
<i>B. pumilus</i>	4.03	1.65	0.875	7.5
<i>B. cereus</i> var. <i>mycoides</i>	10.90	5.30	2.40	7.6
<i>B. coagulans</i> ATCC 7050	6.90	3.53	1.97	9.1
<i>B. laterosporus</i>	5.95	3.13	1.18	7.0
<i>B. circulans</i>	4.75	2.70	1.65	11.5
<i>B. megaterium</i> 9	6.50	2.70	2.35	8.4
<i>B. sphaericus</i>	7.60	4.20	2.25	9.1

temperatures. For the strains of *B. licheniformis*, the A-5 strain was essentially the most heat resistant and ATCC 10716, the least. *B. cereus* strain 7 exhibited higher heat resistance at 95 and 97.5 C and lower resistance at 100 C than did strain 1.

The Z values, which represent the relationship between the rate of change in D values with respect to a change in temperature, are shown in Table 2. The greatest relative resistance to a change in heating temperature was exhibited by spores of *B. circulans* with a Z value of 11.5 and the least by *B. licheniformis* A-1 spores with a Z value of 6.4. For the spores of the 12 organisms studied, the average Z value was 8.2 C.

The Arrhenius plots (Fig. 2) reveal further the differences that exist between the rate of thermal destruction of the various *Bacillus* species and strains. For *B. licheniformis* A-1 and *B. cereus* 7, the slopes

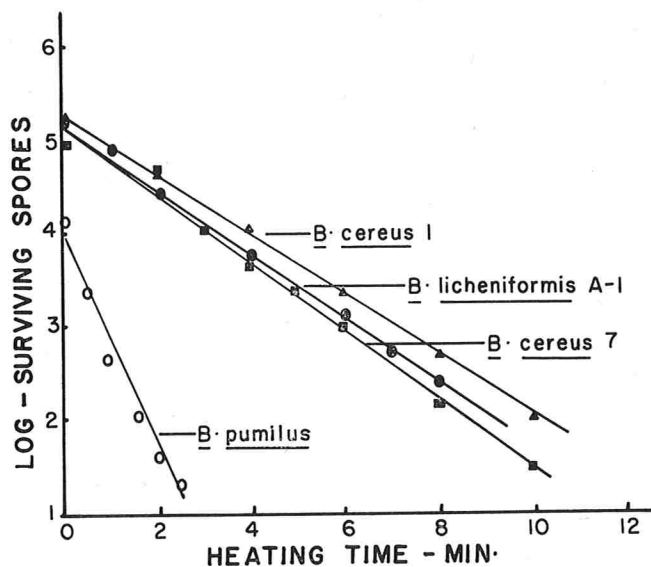


Figure 1. The rate of thermodestruction at 100 C of selected *Bacillus* spores in skim milk.

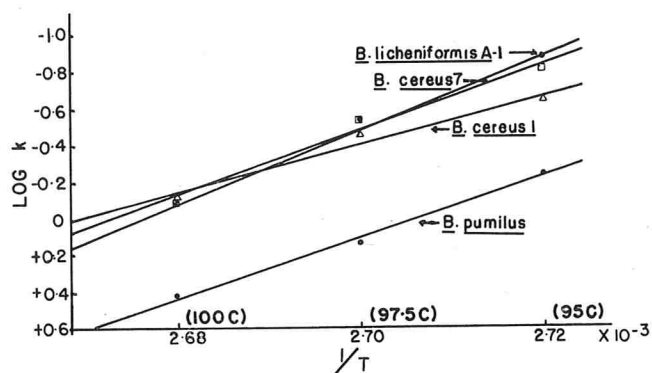


Figure 2. Arrhenius plot of the temperature dependence of the reaction rate constant, k , for the *Bacillus* spores in skim milk.

were essentially the same, exhibiting a progressive increase in the reaction rate as the temperature was increased. At approximately 97 C, the rate of destruction was the same for both of these spores. In contrast, the slope for *B. cereus* 1 illustrates a decelerated rate with increases in temperature, and for *B. pumilus*, a very rapid destruction rate.

DISCUSSION

The establishment of D and Z values in heated milk for a number of spores most commonly found in milk permits comparisons in thermo-resistance between and within species and discloses information as to the rate of survival of spores upon heat treatment of milk.

The D and Z values indicate that some species of *Bacillus* spores are more heat resistant than others

and that considerable variability does exist between strains of any one species at a given temperature. No one strain was consistently the most heat resistant at the three temperatures studied.

The importance of the individuality of the organisms as this relates to their varying heat susceptibility is significant in attempting to establish temperature treatments for the elimination of spores from milk. When a comparison of the heat lability of different sporeforming microorganisms is being made, it becomes necessary to identify both the conditions of heat treatment and the strain or isolate of the given organism being studied.

The results reveal that spores belonging to the genus *Bacillus* will survive in milk exposed to high temperatures. The relatively high D values for *B. cereus* and *B. licheniformis* could account for the observations by a number of workers (2-5) that these two *Bacillus* species are the principal sporeformers encountered in milk.

The findings that the relative heat susceptibility of sporeforming organisms depend upon the heating conditions points up the need for further studies to determine more specifically how the components of the spore respond to heat and why they respond differently as the temperatures are varied. Murrell and Warth (6) attributed differences in the heat resistance of spores to their calcium, diaminopimelic acid (DAP), and magnesium content: Ca and DAP content of the spores increased with heat resistance and that of Mg and the Mg-Ca ratio decreased. Although the exact role by which these agents influence the heat resistance of the spore was not determined in the study, the results suggest that the contractile cortex system of the spore may be involved.

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EGG PROCESSING TECHNOLOGY— PROGRESS AND SANITATION PROGRAMS¹

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ABSTRACT

Egg products, the bulk of which are produced in less than 100 plants operating under continuous USDA inspection, are described. Each year in the U. S. approximately \$130-\$135 million of frozen egg and \$53-\$55 million of dried egg products are produced. Presently 60% of the egg products are consumed as frozen and/or liquid products. These total about 10% of all the eggs consumed (the rest being used as "shell or table" eggs).

The trend toward increased use of egg solids is partially attributable to the ability to complete analysis before incorporating into large batches, which is not possible with defrosted frozen or liquid egg. Specifications and properties of egg products, particularly those of sanitary significance, used to describe purchases for the bakery, confectioners, dry mix and dressing manufacturers, are discussed.

Recent progress in processing technology is reviewed. New egg washing concepts utilizing abrasive brushes, acid cleaners, and iodine containing sanitizers have improved the sanitary quality of raw materials being presented for breaking. Advances in mechanical egg breaking permit more rapid handling of liquid product, resulting in significantly reduced bacteria levels. Glucose removed at low temperatures has resulted in lowered bacteria levels in products to be pasteurized. Advances in pasteurization include consideration of equipment and its use, as well as chemical techniques developed to extend the effectiveness of thermal pasteurization. Drying, one of the most time-honored techniques for food preservation, has brought with it the problem of re-contamination from large volumes of air required. Final dry product in-package pasteurization is now possible with dry egg whites and may be extended to other egg products with fumigants or irradiation.

The egg industry, through the leadership of its trade organization, Institute of American Poultry Industries, has long recognized the need for "self-certification" and initiated sanitary progress and pasteurization even before the so-called "salmonellae problem" was identified by the Communicable Disease Center Salmonella Surveillance Unit.

Recent actions of the regulatory agencies, such as the FDA GMPs, the Public Health Service's proposed ordinance and code regulating the processing of egg and egg products, and Senate File 2116 introduced May 12, 1969 to provide for mandatory inspection of egg products are outlined. The E-3-A program, less than one year old, has gained the support of regulatory agencies, equipment manufacturers, and the egg products industry.

The primary purpose of this presentation is to discuss the further processing technology of the manufacture of liquid, frozen, and dried egg prod-

ucts. We shall review those properties, uses, and processing technology unique to the egg products industry. We shall develop the base on which the unique sanitation programs necessary to produce a product free of public health hazards are founded. In a review of this type, many sources of information, of necessity, have been used and a limited select list of these references has been included in the bibliography.

RAW MATERIALS

The starting raw material for further processed egg products is the shell egg of commerce. The unit in which this product is normally sold is in the 30-dozen case, which yields various egg products as illustrated in Table 1.

The consumption of egg products, shown in Table 2, is approximately 10% of the 320 eggs annually consumed per capita in the U. S. It should be noted that the per cent of the total egg consumption has been rather steadily but slowly increasing over the past 5 years. At the present time, approximately 130-

TABLE 1. TYPICAL CONVERSION FACTORS FOR EGGS AND EGG PRODUCTS

1 case = 30 doz = 47 lb total
= 39.5 lb liquid whole egg
= 17.7 lb liquid whites
= 21.8 lb liquid yolk
= 10.8 lb whole-egg solids
= 2.8 lb egg-white solids
= 8.0 lb egg-yolk solids

TABLE 2. UNITED STATES CONSUMPTION OF EGG PRODUCTS

Year	Shell egg equivalent, per person annually	Per cent of total egg consumption
1950	25	6.4
1955	25	6.7
1960	28	8.4
1961	30	9.1
1962	30	9.2
1963	27	8.5
1964	31	9.7
1965	29	9.2
1966	30	9.6
1967	32	10.0

¹Presented at the Fifty-sixth Annual Meeting of the International Association of Milk, Food, and Environmental Sanitarians, Inc., Louisville, Kentucky, August 17-21, 1969.

135 million dollars of frozen egg and 53-55 million dollars of dried egg are produced annually. About 60% of the total egg products tonnage is consumed as frozen and/or liquid products.

A wide variety of egg products are manufactured for various uses and an illustration of these various types is given in Table 3. Typical purchase specifications for the most common type of egg products are shown in Table 4. These, of course, vary considerably from user to user and from producer to producer, but generally within rather narrow limits. In addition to these basic products, a large number

TABLE 3. EGG PRODUCTS TYPES

<i>Liquid</i>	
White, Yolk, Whole Egg	
<i>Frozen</i>	
White, Whole Egg, Whole Egg w/Yolk added (fortified), Plain Yolk, Fortified Whole Egg w/Corn Syrup, Sugared Egg Yolk, Salted Egg Yolk, Salted Whole Egg	
<i>Dried</i>	
Whites: Spray Dried, Flake Albumen	
Whole Egg & Yolk: Standard Whole Egg Solids, Stabilized (glucose free) Whole Egg Solids, Standard Egg Yolk Solids, Stabilized Egg Yolk Solids, Free Flowing Whole Egg Solids, Free Flowing Yolk Solids	
Blends of Whole Egg & Yolk with Carbohydrates	
With Sugar	
With Corn Syrup	

of blends of yolk, whole egg, and various carbohydrate derivatives and other additives to improve functional performance are manufactured to satisfy the varied demands of the users of egg products.

CONSUMPTION

Essentially all egg products manufactured in the United States, except possibly those purchased for school lunch programs (and many even in that application), are used as ingredients in items prepared for or by bakeries, confectioneries, and institutions, and in mixes and other manufactured foods such as noodles, salad dressing, and mayonnaise. The distribution of uses is shown in Table 5. As indicated earlier, approximately 60% of the total egg products produced are consumed as frozen and liquid product and 40% dried. There has been a gradual but continuing shift from frozen to dried over the last decade in the United States. The trend toward increased use of dried egg solids is based upon several advantages of the more stable product, but of particular concern to sanitarians is the improved sanitary quality that results from elimination of the hazardous thawing process which often results in significant

increases in bacteria counts in the user's establishment. Reuse of egg cans as containers for other ingredients in bake shops has been widely discouraged by public health authorities and egg products manufacturers. A significant advantage only lately realized is the ability of dried egg to be tested for pathogenic organisms, notably *Salmonella*, prior to delivery to the user and in a condition where no further growth is possible, a situation that is difficult to maintain while defrosting frozen egg products.

All egg products play an important functional role or roles as ingredients in those products manufactured by bakeries, institutions, dry mix manufacturers, confectioners, noodle makers, salad dressing and mayonnaise manufacturers, dairy, and baby food producers. A list of these functions is given in Table 6. Several of these functions are adversely affected by heat and other physical treatments encountered during manufacturing technology. The egg sanitarian is primarily concerned with the fact that a limited amount of heat can be applied to pasteurize all egg products. A primary physical manifestation of excess heat is an immediate and rapid setting up of a thick gel, making pumping or further processing impossible. While these temperatures vary with degree of dispersion; pH; length of holding time; and presence of salt, sugar, or other protective materials, pasteurizing times and temperatures indicated later are basically the maximum temperatures to which the particular products can be heated, the functional properties indicated above maintained in a usable form, and the product still capable of being handled

TABLE 4a. SPECIFICATION GUIDE.¹

	Frozen		
	Whites	Plain yolk	Whole
Moisture (solids)	11.8% min.	43.0% min.	26% min
Fat	0.02% max.	25% min.	11% min.
pH	—	—	—
Protein	10.5% min.	16.0% min.	12.5% min.
Carbohydrate	—	—	—
Color	—	SOP	SOP
Viable bacteria	50,000/gm max.	10,000 max.	10,000 max.
Yeast	—	10 max.	10 max.
Mold	—	10 max.	10 max.
Coliforms	1000/gm max.	10 max.	10 max.
Salmonella	Negative	Negative	Negative
Granulation	—	—	—
Specification	—	—	—
Additives	—	—	—
Performance	SOP	SOP	SOP

¹SOP, specified on purchase; SS, sodium silicoaluminate; SLS, sodium Lauryl sulphate.

TABLE 4b. SPECIFICATION GUIDE.¹

	Solids				Fort. whole egg with CHO
	Angel whites	Flake albumen	Stabilized whole	Stabilized yolk	
Moisture (solids)	8% max.	14% max.	5% max.	5% max.	4% max.
Fat	Nil	Nil	40% min.	57% min.	32% min.
pH	7.0 ± 0.5	5.5 ± 0.5	7.5 ± 0.5	6.5 ± 0.5	7.5 ± 0.5
Protein	80% min.	75% min.	48% min.	32% min.	29% min.
Carbohydrate	Nil	Nil	Nil	Nil	30% max.
Color	Creamy	Clear Yellow	NEPA 2 to 4	NEPA 2 to 4	—
Viable bacteria/g	10,000 max.	10,000 max.	10,000 max.	10,000 max.	10,000 max.
Yeast/g	10 max.	10 max.	10 max.	10 max.	10 max.
Mold/g	10 max.	10 max.	10 max.	10 max.	10 max.
Coliforms/g	10 max.	10 max.	10 max.	10 max.	10 max.
Salmonella	Negative	Negative	Negative	Negative	Negative
Granulation	100% thru	—	100% thru	100% thru	100% thru
Specification	USBS-80	—	USBS-16	USBS-16	USBS-16
Additives	SLS 0.1% max.	—	—	SS 2% max.	—
Performance	SOP	SOP	SOP	SOP	SOP

SOP, specified on purchase; SS, sodium silicoaluminate; SLS, sodium lauryl sulphate.

TABLE 5. USAGE OF EGG PRODUCTS IN UNITED STATES, BY TYPE OF USER, 1966. B, BAKERIES; I, INSTITUTIONS; M, DRY MIX MANUFACTURERS; C, CONFECTIONERS; N, NOODLES, S, SALAD DRESSING AND MAYONNAISE; D, DAIRY AND BABY FOOD. PERCENTAGE CALCULATED ON LIQUID EQUIVALENT BASIS

Type	Principal Users	Per cent of Total
Whole Egg		
Frozen	B, I	31.5
Dried	B, I, M	19.0
		50.5
Albumen		
Frozen	B, C	12.2
Dried	B, C, M	16.4
		28.6
Yolk		
Frozen salted	S	6.9
Frozen sugared	B, D	5.3
Frozen plain	B, N	4.6
Dried	M	4.4
		21.2

mechanically.

On the other hand, the unique nutritional properties of eggs afford an environment in which many organisms can multiply rapidly. This potential problem is accentuated by the fact that the bird is a natural host for *Salmonella* organisms and the process of oviposition is not conducive to microbiologically clean surfaces on egg shells. Another unique property contributing to the need for comprehensive sanitation programs is the fact that the egg shell contains 6,000-8,000 tiny pores through which many organisms can travel under proper conditions. With

these properties in mind, let us now look at several of the manufacturing technologies in which sanitation programs are of critical importance.

MANUFACTURING TECHNOLOGY

It does not appear to be feasible to discuss all of the manufacturing technology steps as are illustrated in Fig. 1, although at each step there can be significant sanitation hazards. The following steps will be discussed: egg washing, egg breaking, sugar removal, pasteurization, drying, and dry heat treatment.

Even the best husbandry or "good manufacturing practices" during production and assembly operations, although yielding a very high percentage of visibly clean shells, generally gives a raw material with fairly high microbiological loads on shell surfaces and if improper holding conditions have been

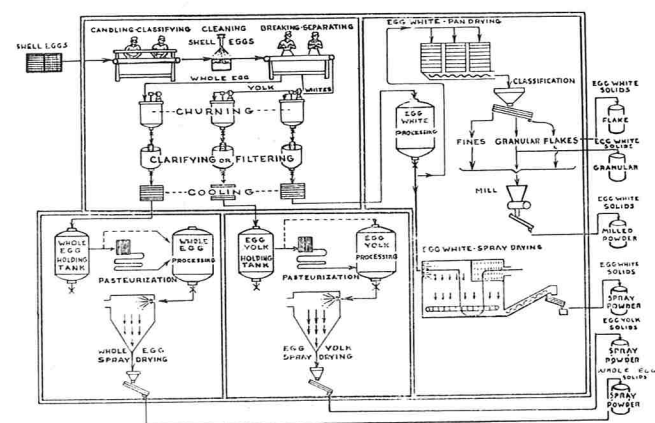


Figure 1. Schematic flow chart of egg breaking and dehydration operations.

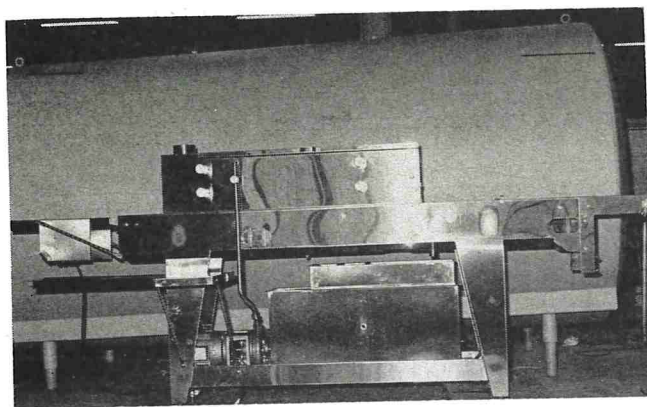


Figure 2. Side view of automatic egg washer; eggs feed from left to right through candling and inspection, washing, rinsing and sanitizing, drying, and discharge.

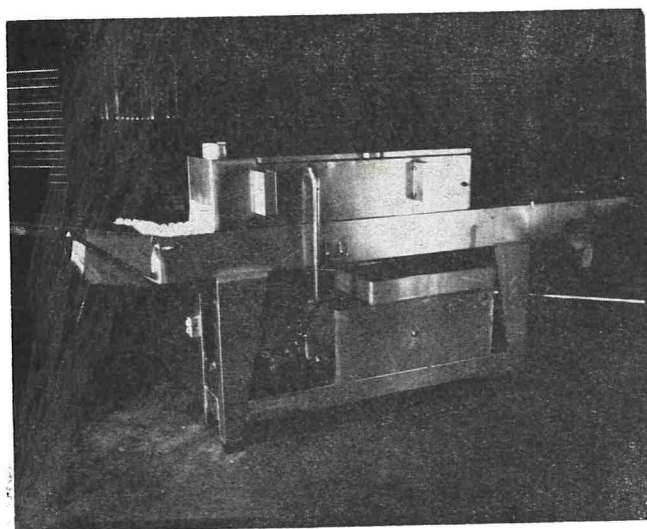


Figure 3. Eggs on candling and inspection table where defects are removed by skilled operators.

encountered, shell penetration results in contaminated contents. In addition to the contamination of sound shell eggs from the environment, the high speed handling equipment encountered in modern egg processing plants results in "checks" or small cracks in the egg shell whereby the possibility of organism penetration is greatly increased. Present regulations permit handling of eggs with cracked shells if the membrane is intact but broken shells and membrane result in a rejected egg. In this country it is common practice to wash all eggs presented to the egg breaking equipment. The bacteriological, chemical, and physical requirements for commercial egg cleaning have been investigated by many workers. Figures 2 thru 4 illustrate the basic sanitation principles involved in the egg washing operation. Stainless steel throughout is required to permit the use of cleaning materials of sufficient efficiency to ensure clean eggs without corrosion of equipment. Egg washing machines are currently under study by a task group of the E-3-A Standards

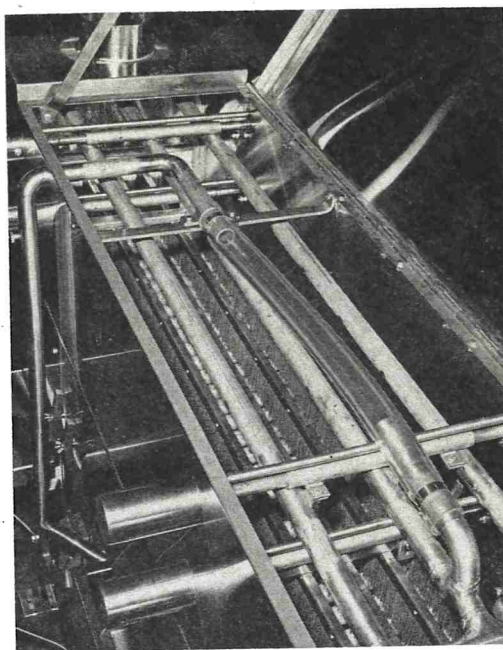


Figure 4. Oscillating brush and water wash spray area opened for inspection. Sanitizing area to extreme right protected from wash water splashing.

Committee. A candling step, as illustrated in Fig. 3, is critical to remove eggs that might have interior spoilage, as well as open leakers or excessive dirt. Figure 4 shows the bristles of the oscillating brushes which, in many instances, are impregnated with an abrasive material to assist in the cleaning operation. Large sprays of water at 120 F containing a suitable

TABLE 6. FUNCTIONAL PROPERTIES OF EGGS

Whipping
Emulsifying
Binding
Coagulation
Flavor
Texture
Color
Nutrition

chlorinated-alkaline detergent are sprayed with pressure over the surface of the brushes and eggs. At present, economics necessitates some recirculation of water, but with modern egg washing machines, strainers remove any particulate matter and regular overflow maintains the wash water in proper condition. The final stage in the washing operation is the rinse. This rinse can be 200-500 ppm chlorine and while iodine compounds have not been generally accepted by regulatory agencies, they are much more effective in the sanitizing step than are the chlorine compounds. When eggs are to be broken, there is no need for drying since they move in a continuous manner to the egg breaking machine as will be shown

later. A properly operated egg washing machine presents essentially sterile eggs to the egg breaking machine with only minor temperature increases (5-10 F) in the content of the egg. The temperature rise factor is extremely important as it is imperative to reduce the temperature of broken out whole egg to below 40 F as rapidly as possible, and in no event longer than 2 hr.

Egg breaking and separation

The breaking and separation of shell eggs to remove the edible portion from the shell and to separate the edible portion into yolk and white has long posed serious technological problems for the egg products manufacturer. The now outmoded hand breaking operation shown in Fig. 5 permitted breakers to inspect the eggs and remove any inedible or suspect eggs, to keep yolk contamination of whites at a minimum, and to reduce the egg white retained within the shell to the lowest possible level.

As egg breaking operations became more refined and the labor market more restricted, automatic egg breaking machines were developed. Figures 6-10 illustrate the steps involved in mechanical breaking of eggs at rates up to 40 cases per hour. Quite obviously with machine breaking the problems of yolk contamination, excessive production of whole egg, and inspection of eggs for insipient spoilage or other defects becomes more difficult and critical. Rapid automatic egg breaking equipment depends upon a uniform supply of high quality sound shelled eggs for its most efficient use. The temperature of the egg at the time of breaking is critical for if it is too warm the yolk membrane is weaker, resulting in excessive breakage and contamination of whites along with excellent opportunities for bacterial development, but if the egg is too cold it is impossible to separate the white from the yolk resulting in excessive amounts of white being retained with the yolk, making it impossible to meet the standard of identity of 43% solids in the yolk product. In all instances, egg is cooled as rapidly as possible following the egg breaking operation.

Glucose removal

The process involving glucose removal, commonly called fermentation, must be routinely applied to egg white liquid that is to be dried and is often applied to yolk and whole egg containing products to be dried if considerable stability is required. Fermentation is not required for products to be frozen or used in a liquid state. Obviously the process of fermentation in itself can create serious microbiological and sanitation problems. Development of the art of glucose removal is buried in antiquity but its effect

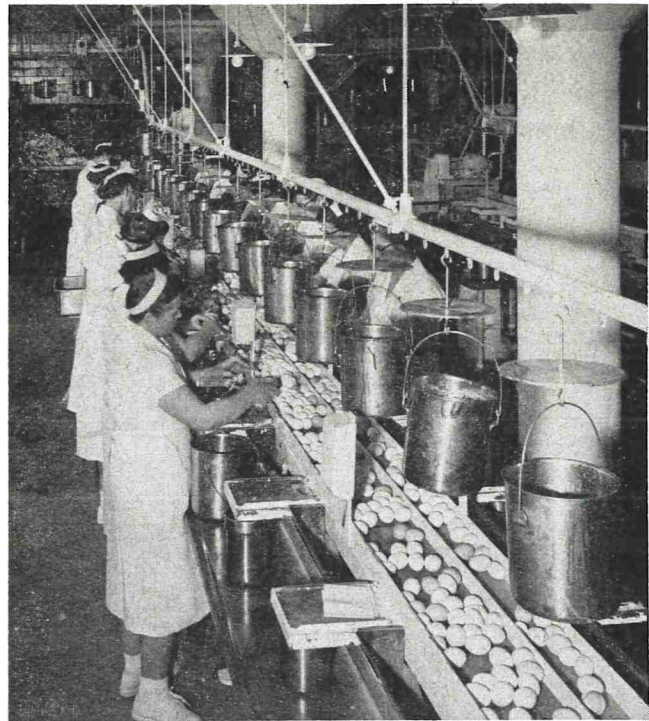


Figure 5. Obsolete hand breaking operation. Eggs moved on belts to "breakers"; pails of product moved by conveyor to inspector station.

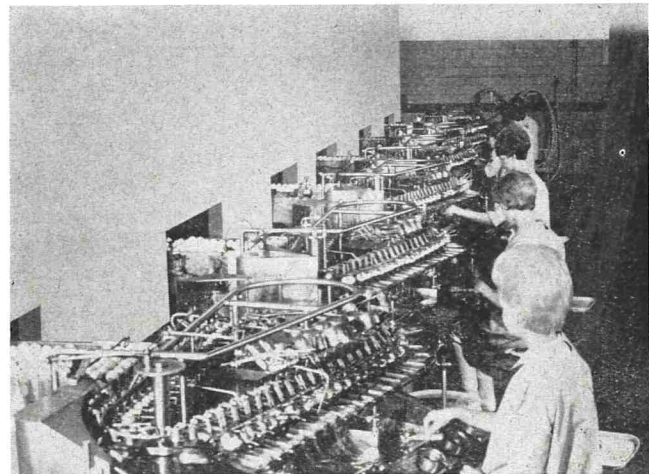


Figure 6. Battery of six automatic egg breaking machines. Machines individually controlled by foot operated switch.

was first explained in the early 1940's by laboratories working independently in England, Canada, and the United States. It was necessary to prevent the so-called browning or Maillard reaction in which the aldehyde groups of the carbohydrate reacted with the amino groups of the proteins to form an insoluble brown off-odored compound. Removing one of the reactants (glucose) stopped the reaction. Several procedures for removing glucose have now been developed. They may be classified into three types based upon the use of (a) bacteria, (b) yeast, and (c) enzyme, glucose oxidase. The bacterial fer-

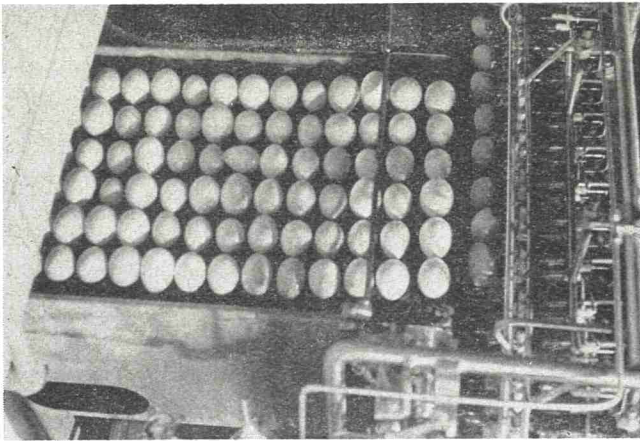


Figure 7. Eggs being delivered to breaker following inspection, washing and sanitizing.

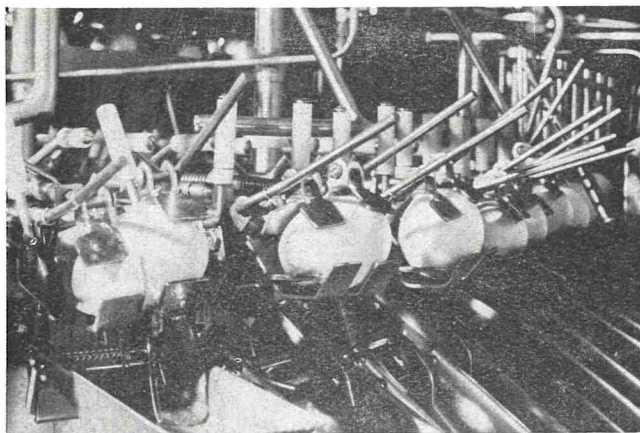


Figure 8. Eggs firmly held by stainless steel "fingers" are opened by sharp blow from undercutting double blade knife. Knife blades open to spread shell and permit contents to fall into separating and inspection cups.

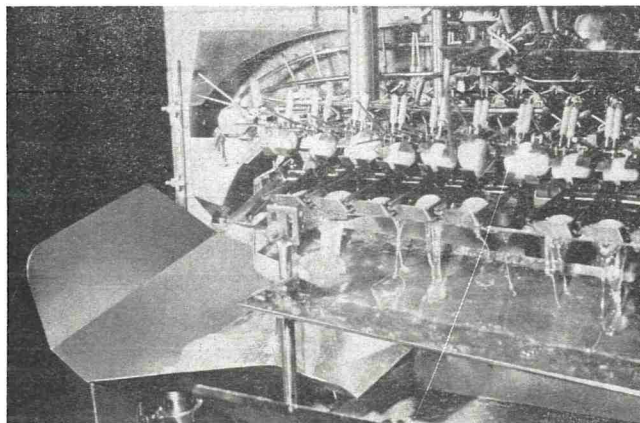


Figure 9. Eggs passing in view of inspector-operator while yolks and whites are being separated by specially designed cups.

meritation, using a variety of glucose fermenting organisms, is carried out by reducing the pH of pasteurized egg white to 7.0-7.5 with an edible acid such as lactic, at which time a culture of the desired organism, such as *Aerobacter aerogenes*, is added.

Fermentation is allowed to continue for 12-24 hr at 30-33 C until the glucose is removed as indicated by laboratory analysis (Clinistix). The product is cooled rapidly to stop the fermentation and is then held for drying. Bacterial fermentation is generally considered the most desirable for egg white because it results in a high whipping product with good odor and solubility. Bacterial fermentations have never been satisfactory for whole egg or yolk because of the off-odor and flavor developed in these products. Use of frozen or dried cultures of organisms, as has been common in the dairy industry for some years, is only now receiving attention in the research laboratories of the egg products industry. It is predicted that within a few years widespread use of such cultures will result in better quality egg white.

Development of the yeast fermentation using *Saccharomyces cerevisiae* has had limited use since it is patented by one firm. A disadvantage of this product is the "yeasty" odor that is sometimes encountered. An advantage is the ready availability of pure cultures of the fermenting organism.

The enzyme procedure involves addition of hydrogen peroxide to furnish a source of oxygen after appropriate pH adjustment, in the presence of glucose oxidase (commercially available), with the result that glucose is oxidized to gluconic acid, a non-reactive form of glucose. Recently a process has been developed for cold desugaring, which takes place at approximately 10 C although the time required for sugar removal is somewhat longer. Use of lower temperatures permits lengthening the desugaring process and decreasing the amount of enzyme used and offers interesting possibilities in the production of low bacteria count yolk, whole egg, and egg white products.

Pasteurization

Control of organisms in foods begins with the hus-

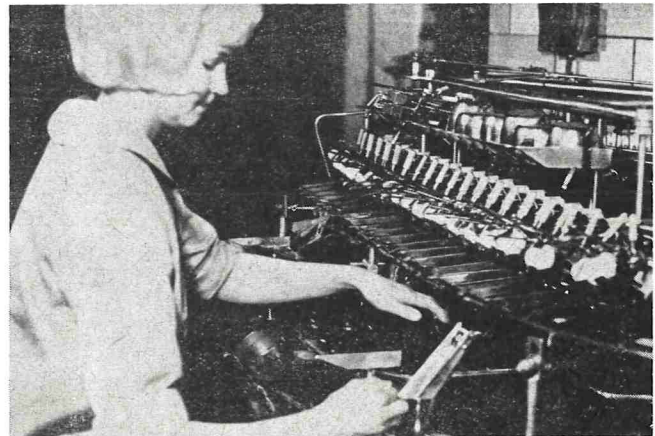


Figure 10. Inspector-operator removes entire separator cup if defective egg is not detected by earlier "in-shell" inspection. Cup is washed and sanitized before replacing in system.

TABLE 7. BASIC PASTEURIZATION PROCESS FOR EGGS

Heating egg liquid
 Heating dried egg
 Treating liquid with H₂O₂

TABLE 8. PASTEURIZING WHOLE EGG AND YOLK PRODUCTS

Plain whole egg liquid

140 F for at least 3.5 min

Plain yolk liquid

142 F for at least 3.5 min, or

140 F for at least 6.2 min

Yolk with carbohydrate

146 F for at least 3.5 min, or

144 F for at least 6.2 min

Yolk with salt

146 F for at least 3.5 min, or

144 F for at least 6.2 min

TABLE 9. PASTEURIZING EGG WHITE

Plain liquid egg white (pH 9.0)

134 F for at least 3.5 min

Stabilized liquid egg white (pH 7.0 & with aluminum sulfate added)

140 F for at least 3.5 min

Plain liquid egg white (pH 9.0) in presence of H₂O₂

125 F for at least 2 min

Dried egg white

For spray albumen—130 F for 7 days

For pan albumen—125 F for 5 days

bandry practices and continues with the various food processing operations with the object of reducing or preferably eliminating spoilage and wastage of the food product and eliminating any health hazard that might result from product consumption. When sterilization is impossible, as with eggs because of the heat lability of the proteins, numbers of pathogens must be reduced to ensure that poor handling practices by food handlers and consumers result in minimal human health hazards. The problem of salmonellosis in eggs has been adequately reviewed in a number of outstanding publications and will not be repeated here.

Pasteurization technology for whole egg and egg white has, of necessity, been based on lower temperatures than would be desirable for maximum destruction of pathogens because of the heat lability of the egg proteins. Qualities that are of particular value in the baking industry, as indicated above, must be preserved if the egg is to be used satisfactorily for its intended purposes. Various methods for destroying organisms are available to the food

technologist and most have been applied to egg products.

Chemical additives have not been generally accepted as approved methods for reducing microbiological contamination. Irradiation of food products, using a wide variety of energy levels, also has found its way into egg products technology research. Microorganism levels can be effectively reduced but off-flavors and odors are induced and the possibility of health hazards still exist. The effective basic pasteurization processes for eggs are illustrated in Table 7. Conditions commonly employed for pasteurization of yolk and whole egg are shown in Table 8. The higher temperatures that can be used with carbohydrate-containing materials are required because of the protective action of the carbohydrates for microorganisms. Pasteurization of egg whites is much more critical and the basic procedures are outlined in Table 9.

Conventional high temperature short time equipment, either of the plate and frame variety or the triple tube type, is commonly employed in the egg industry. Some batch pasteurization has been used experimentally but it has not received wide acceptance in this industry. Effective control of egg pasteurization depends upon laboratory assays to a much greater extent than in the milk industry where higher temperatures can be employed and where sufficient experience has indicated that a given set of conditions will result in a satisfactory product. In the egg industry where these temperatures cannot be employed, thorough analysis for pathogenic organisms is indicated, thus making it difficult for small operators who might otherwise use small batch pasteurizers to have an effective quality control program.

Current pasteurization requirements are listed in the USDA Regulations and are discussed in detail in the Egg Pasteurization Manual prepared by the Poultry Laboratory of the Western Utilization Research and Development Division under the direction of Dr. Hans Lineweaver (ARS 74-78, February, 1969). A review draft of *Ordinance and Code Regulating the Processing of Eggs and Egg Products—1968 Recommendations* has been prepared by the Department of Health, Education, and Welfare of the Public Health Service in January, 1968, and received wide industry review.

Drying

Eggs are commonly dried on the same type of equipment used in the dry milk industry and the same type of problems encountered there with removal of micro-organisms from large quantities of air receive serious attention of the egg products sanitarian. Absolute filters are used in most in-

stallations and in all those where products go into critical uses. Contrary to popular belief, heat involved in drying operations is not very effective in reducing bacteria counts because of the tremendous evaporation rates from the small particles during the drying cycle. Fat-containing egg products must be cooled to prolong shelf life. In the past, considerable difficulties have arisen from the use of refrigerated air for this purpose. The cooling problem has been effectively solved, although at a somewhat excessive cost, by use of liquid carbon dioxide atomized or sprayed into a moving belt or auger of the warm material. Drying heat can be removed at a cost of from 1/4-1/3 cent per pound to a temperature of 85 F. Egg dryers are constantly on the alert to avoid recontamination with pathogens during the drying and packing operations.

Heat treatment

A second form of pasteurization can be applied to dried egg white when glucose removal extends shelf life under high temperature conditions. Following bulk packing, the egg white is subjected to dry heat within the sealed container at temperatures varying from 125-130 F for 7-10 days exclusive of "come up time" for powder of approximately 6% moisture. Lower moisture levels require longer heating times. Specific times and temperatures are spelled out in proposals currently under consideration by the USDA for inclusion in their regulations. It has been suggested that when these proposals have been approved, the term "pasteurization" be applied to this form of heat treatment thereby eliminating the confusing terminology in the consuming trade. An obvious advantage of this type of pasteurization for the in-package treatment is the elimination of recontamination possibilities. A recent report entitled *An Evaluation of the Salmonella Problem* prepared by the Committee on Salmonella, Division of Biology and Agriculture of the Natural Research Council at the request of the U. S. Department of Agriculture and the Food and Drug Administration, outlines a great number of control techniques and discusses in detail the lots, samples, and analytical sensitivity in the analysis of dried egg yolk and whole egg for salmonellae. Appropriate lotting, sampling, and analytical plans have been discussed adequately in the literature and cannot be reviewed here.

IN-PLANT SANITATION

Full sanitation programs in the egg products industry generally are carried out by the individual firms' quality assurance personnel in cooperation with the resident USDA inspectors found in most plants. The points of concentration are as follows: (a) raw material inspection, (b) in-process surveillance,

(c) end-product analysis, and (d) environmental audit.

Raw material inspection is accomplished by examining the shell eggs in the cases as they enter the plant, the condition of the cases, the condition of the truck, and either sample or total candling of the eggs to determine their wholesomeness. Regular records of the amount of inedible loss are kept and serve as important bases for continuing supplier review.

In-process surveillance is accomplished by a cooperative effort of the resident inspector and the quality assurance supervisor through the regular keeping of records of temperatures, examining recorder charts, pasteurization charts, flow diversion valve operation, drying temperatures, etc. In-process surveillance is of utmost importance in the maintenance of final product quality.

As indicated in specifications earlier, a number of chemical, microbiological, and physical tests are routinely employed to determine not only the wholesomeness but the functionality of the product. It is of little concern that an egg product of excellent sanitary properties might be produced if it is impossible to fulfill the function for which it was intended. A balance of quality traits must be maintained.

And finally continuing environment audit must be maintained. Appropriate insect and rodent control programs often are supervised by consulting agencies, while a full time sanitarian is employed in each plant to ensure that necessary bait boxes, insecticides, etc., are on hand and used properly. Constant air sampling ensures that recontamination of product can be kept at a minimum.

EXTERNAL SANITATION INFLUENCES

A number of agencies and organizations have had continuing interest in the sanitary programs of the egg products industry. Each of these in their own way, has contributed toward the increasing level of sanitation that we see in the industry today.

Institute of American Poultry Industries

The egg products industry has been fortunate in that its trade organization has maintained an interest in sanitation dating to the early 1950s when the *Salmonella* problem first arose. Sanitation manuals have been prepared by its sanitation committee and widely used in the industry. The Research Council of the Institute has been active in urging research to improve pasteurization techniques for egg products, as well as to suggest improved methodology for detection of *Salmonella* and other microorganisms. The Institute has worked actively with the Food and Drug Administration, the Communicable Disease Center, the Public Health Service, the U. S. Department of Agriculture, and other interested

governmental agencies, not just in demonstrating to these agencies the progress that the industry has made but even more importantly holding schools and seminars where industry technicians could be taught the principles of sanitary practices. The Institute maintains a laboratory which is widely used as a referee laboratory by all firms and is a valuable adjunct to their quality control laboratories.

Dairy and Food Industries Supply Association

The DFISA and IAPI have collaborated in development of E-3-A type standards for equipment to be used in the egg products industry. Although a new development, several standards have been modified slightly to make them applicable to the egg industry and will be shortly published in the *Journal of Milk and Food Technology*. Additional existing standards are currently being modified and two of the processes outlined earlier—egg washing and egg breaking—have had task force committees appointed and exploratory studies are under way.

Food and Drug Administration

The Food and Drug Administration, in addition to its regulatory activities, has been extremely helpful to the egg products industry by sponsoring seminars and workshops, in some instances jointly with the industry. These sessions have dealt primarily with the materials covered in the Good Manufacturing Practices for the egg industry and related industries and have proven to be very valuable to a better understanding of sanitary principles. Food and Drug's active interest in *Salmonella* has resulted in standardization of methodology for detecting this organism. As a result of their interest, along with those of other agencies, the *Salmonella* problem in egg products has been virtually eliminated.

U. S. Public Health Service

Prior to recent reorganization of the U. S. Public Health Service within the Department of Health, Education and Welfare, this group was very active in promulgation of a model code for pasteurization of egg products. This group has been active in the E-3-A Standards and has worked closely with the IAPI Research Council and sanitation committees on specific problems as they have arisen.

U. S. Department of Agriculture

The USDA's Consumer and Marketing Service has maintained a voluntary egg products inspection program for many years. This program of continuous resident inspection has been effective but suffered from the disadvantage of being voluntary. USDA has maintained primary regulatory control over the egg products industry, although at times disagreements with other government agencies, notably the Food and

Drug Administration, have resulted from overlapping responsibility. This has never been a continuing serious problem but has caused considerable local irritation from time to time. A bill, Senate File S.2116, was introduced into the Senate on May 12, 1969, and referred to the Committee on Agriculture and Forestry. This bill is "to provide for the inspection of certain egg products by United States Department of Agriculture; restriction on the disposition of certain qualities of eggs; uniformity of standards for eggs in interstate or foreign commerce; and cooperation with state agencies in the administration of this act; and for other purposes." Under this bill, to be administered by the Department of Agriculture, the cost of inspection under the act would be borne by the United States Government for the most part, except where overtime or holiday work might be carried out at the request of the individual firm. This bill has received quite wide acceptance from the egg industry and apparently from those government agencies which would be involved in its administration. It is quite widely believed that, barring unforeseen circumstances, there may be some favorable action on this before the present session of the Congress closes.

While there are undoubtedly exceptions, it is felt that the state of sanitation programs in the nearly 100 plants operated under continuous resident USDA inspection are at as high a level as sanitation programs in any of the food industries. Egg products processed under these conditions have not been implicated in any cases of food poisoning in the last 2 years. Seizures by the FDA for any cause have been greatly reduced and in most instances confined to plants not being operated under inspection. We feel that properly operated quality assurance programs can result in true "self certification" and, with the help of government agency inspection primarily for those firms who are not able to impose their own restrictions, egg industry sanitation levels will be maintained and improved as technology permits.

ACKNOWLEDGMENT

Thanks are extended to the Paul Mueller Company, Springfield, Missouri, for photographic assistance and to Drs. Bergquist and Cunningham of Henningsen Foods for valuable help and advice on this manuscript.

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OUR HOSTS 57TH ANNUAL MEETING IOWA ASSOCIATION OF MILK, FOOD AND ENVIRONMENTAL SANITARIANS, INC.

The 1st annual meeting of the Iowa Association of Milk Sanitarians was held on February 19, 1942. Officers elected were Dr. M. P. Baker, President; Milton E. Held, Vice President; J. R. Jennings, Secretary-Treasurer. At this meeting the Secretary-Treasurer was instructed to contact the International Association of Milk Sanitarians to ascertain the formalities required for affiliation with the International Association. During this same year the Iowa Association of Milk Sanitarians was made an affiliate of the International Association of Milk Sanitarians.

In 1969 the name of the Iowa Association was changed to Iowa Association of Milk, Food and Environmental Sanitarians, Inc.

The Iowa Association has grown from the 27 charter members to its present membership of 173.

The 1961 International Association meeting, which was the 50 year Golden Anniversary meeting, was held in Des Moines, Iowa.

It is timely that the 1970 International convention be held in Iowa with Milton E. Held as President of the International Association of Milk, Food and Environmental Sanitarians, Inc., as Milt was the first Vice President in the founding of the Iowa Association 28 years ago.

Ray Belknap, Past President of the International Association has been a member of the Iowa Affiliate since 1948, serving as President during the year 1954.

ACKNOWLEDGEMENT OF ASSISTANCE BY REVIEWERS

The Editor acknowledges with thanks the help provided by members of the Editorial Board in the review of manuscripts. Particular thanks goes to those Board members who did extra work while three other members of the Board were in foreign countries. The Editorial Board has been enlarged and the Editor expresses his appreciation to the following for their willingness to serve in this capacity:

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tana

During this past year some manuscripts were reviewed by persons not on the Editorial Board. Their help was enlisted when, in the opinion of the Editor, special expertise was needed to evaluate certain manuscripts submitted for publication. Appreciation for their assistance is extended to:

Dr. R. L. Bradley, Jr.
Dr. H. E. Calbert
Dr. O. R. Fennema
Dr. R. C. Lindsay

Dr. N. F. Olson
Dr. M. L. Speck
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Dr. W. C. Winder

LETTER TO EDITOR*NMC responds to joint meeting*

DEAR SIR:

On behalf of the National Mastitis Council, I express our gratitude and appreciation for the opportunity and invitation to hold our 1969 regional meeting in conjunction with your (IAMFES) annual meeting at the Brown Hotel in Louisville.

The high percentage of our Board members who are also members of your organization (IAMFES) in attendance made it possible for us to have a very successful Board meeting which I hope will help us further our cause and achieve the

goals we have set forth.

Largely due to your support, we feel that our regional meeting on Monday was highly successful and interesting to those in attendance. We certainly hope that our meeting was in no way a deterrent to yours.

Sincerely,

JAMES B. SMATHERS

*President**National Mastitis Council**Maryland and Virginia Milk Producers Assoc.**1530 Wilson Blvd.**Arlington, Virginia 22209***NEWS AND EVENTS****HOUSEKEEPING SEMINARS FOR SPRING
1970 ANNOUNCED BY S-E-A**

The 1970 seminars in Housekeeping Management and Supervision announced by Service Engineering Associates, Inc., have been especially designed for those who are concerned with meeting the challenge of new requirements confronting the manager and supervisor in this field and with the best ways to apply newly available cleaning technology. S-E-A is an independent consulting firm of registered engineers and sanitarians serving schools, hospitals, industry, buildings, commerce and government.

The announcement of this—the nineteenth series of seminars offered by this firm—was made by Edwin B. Feldman, P.E., President of S-E-A and author of numerous books and articles on sanitation. The seminars are scheduled as follows:

Dallas	March 2-4
Cleveland	March 11-13
Chicago	March 23-25
New York	April 1-3
Washington	April 6-8
San Francisco	April 20-22
Philadelphia	April 29-May 1
Los Angeles	May 4-6
Toronto	May 20-22
Atlanta	May 25-27

The speakers will include Keith A. Fitch, Professional Engineer and Registered Sanitarian; Clifford C. Groover, Professional Engineer and labor specialist; as well as Mr. Feldman.

Most of the talks are slide-illustrated. The presentations also include demonstrations of techniques for increasing supervisory skills. Audience Research Projects sessions will be devoted to solution of pre-submitted problems.

The course is designed for executive housekeepers, physical plant directors, sanitarians, plant engineers, building superintendents and managers, housekeeping foremen and supervisors, methods analysts, maintenance directors, suppliers and contractors. Thousands of such persons have attended S-E-A seminars over the past eight years.

The registration fee is \$100, with group rates available. A free brochure provides the complete program, a list of previous participants, biographical data concerning the speakers, and registration form. A special offering is made of the company's two books, "How To Use Your Time To Get Things Done," and "Housekeeping Handbook for Institutions, Business and Industry." Write: Service Engineering Associates, Inc., 3954 Peachtree Road, N.E., Atlanta, Georgia 30319, Telephone: 404/261-2050.

SAFETY IN THE LABORATORY

The Training Institute of the Environmental Control Administration is presenting the course, "Safety in the Laboratory", The course location and date are Cincinnati, Ohio, March 30-April 3, 1970.

Applications for the course may be submitted to the Director, Training Institute, Environmental Control Administration, P. O. Box 30200, Cincinnati, Ohio 45230.

This course is intended to train safety managers, laboratory staff members and related workers in accidental injury control. The course provides an opportunity for existing staff members to be re-appreciated of the facilities and methods at their disposal to minimize the occurrence of injury in the laboratory.

Administrative and organizational aspects as well

as design and construction of laboratory equipment and facilities will be discussed. This includes discussion of plumbing, electrical, and other appropriate standards. Methods of handling reagents, biological, pathological, radioactive materials, and various specimens will be reviewed. Animal care and related facilities, protection from extreme temperatures, and waste storage and disposal are included. In addition, the trainee will have opportunity to investigate ventilation systems, diseases transferable to man, emergency aid, and other pertinent subject matter.

FORUM ON POLLUTION ABATEMENT OUR HOSTS 57TH ANNUAL MEETING

Waste water management in the food processing industry was submitted to intensive study during a six-day conference at Pacific Grove, Calif., January 25-30, 1970 under the chairmanship of Robert I. Lachman, of the N. Y. State College of Agriculture at Cornell University.

Lachman, technical services engineer in the department of food science, reports that the Engineering Foundation-sponsored research conference brought environmental consultants together with food processors to explore the problems of developing pollution abatement programs for the food industry.

Among those who participated in the technical conference are waste water management experts and consulting engineers from government, education, and industry.

Major sessions of the conference were devoted to waste water management, the role of the food processing industry in pollution abatement, waste treatment procedures, cost reduction methods, and forms of financing.

The Engineering Foundation research conferences aim to provide an opportunity for the exploration of problems and issues that confront engineers from many disciplines, according to Lachman.

NATIONAL WORK SHOPS ON ENVIRONMENTAL HEALTH EDUCATION APRIL 8-10, 1970

A national work shop on environmental health undergraduate education will be held at Indiana State University, Terre Haute, Indiana, April 8, 9, 10, 1970. Authoritative speaker will include Jerrold Michaels, Assistant Surgeon General, U. S. P. H. S., Larry Gor-

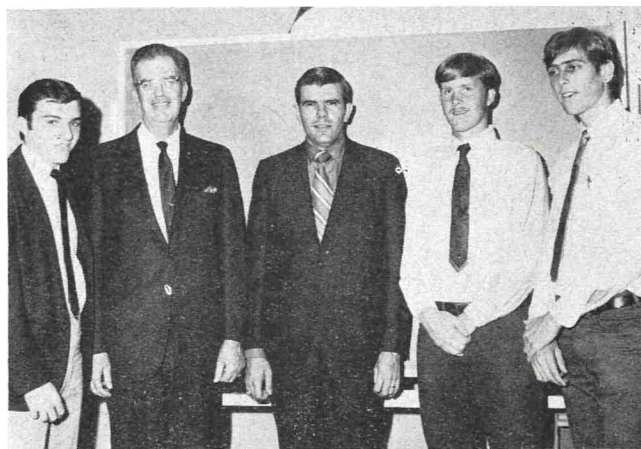
don, Director Environmental Health, New Mexico and Bailus Walker, Deputy Commissioner of Health, Cleveland, Ohio and other well known leaders in the field.

Competencies sought by potential employers of the environmental health majors will be determined and an attempt will be made to assess essential content of the curriculum for career preparation.

Attendees will include state President of IAMFES, Inc., NEHA, Directors of Environmental Health, Coordinators of University Environmental Health programs and Sanitarian Registration Board Presidents.

WYANDOTTE OFFICIAL GIVES PRESENTATION ON SANITATION TO TEXAS A&M FOOD PLANT MANAGEMENT CLASS

Mr. Jerry L. McFarland, assistant to Marketing Manager, Food Industries Products, Wyandotte Chemical Corporation recently addressed the Food Plant Management Class at Texas A&M. He discussed "The Total Sanitation Program." Mr. McFarland stressed the coordination of all the elements to secure this program—including mechanical innovations, environmental changes, new chemical developments, and personnel management.



Pictured left to right: Al Diorio, Dr. Carl Scholle, Jerry McFarland, James Bocklet, and David Klavens.

NEW CONCEPT IN MUNICIPAL INCINERATION

City officials in Shelbyville, Indiana, working under a Federal grant, will evaluate a completely new con-

cept in municipal incineration. Richard D. Vaughan, Director of the Environmental Control Administration's Bureau of Solid Waste Management, announced a \$276,453 award for the study of a high temperature vortex incineration system. ECA is a unit of the Department of Health, Education, and Welfare's Consumer Protection and Environmental Health Service. The city of Shelbyville will provide \$138,227 as its share of the total \$414,680 first-year costs.

The system was originally designed by the General Electric Company, and installed at the GE plant in Shelbyville to dispose of industrial refuse from the plant. Preliminary tests indicate that the incinerator can also handle refuse from the city of Shelbyville and Shelby County, serving a population of 40,000. Mr. Vaughan observed that if the project is as successful as now appears likely, hundreds of small communities across the Nation could benefit.

In the vortex system, refuse is shredded and blown into a horizontal combustion cylinder, where the waste particles burn while suspended. Unlike a conventional incinerator system, it requires no grates, and no quench tanks for cooling the residue. The present pilot-sized unit has a capacity of 2 tons of refuse per hour, and reduces the volume of municipal refuse by at least 97%. It is anticipated that the system will provide an economic alternative to sanitary landfilling for the small community. The system has potential for application in large communities as well. By locating several 5-ton per hour units in a large metropolitan area, refuse haul distances could be reduced, with corresponding reduction in collection costs. For example, a unit might be conveniently located to process the waste from a residential development or large shopping center.

Mr. Anthony W. Fraps, of Fraps and Associates, Inc., Indianapolis, Indiana, will direct the two-year project for Shelbyville officials.

INDEX TO ADVERTISERS

Babson Bros., Co.	Back Cover
Difco Laboratories	II
IAMFES, Inc.	VI
Klenzade Products, Division of Economics Laboratory, Inc.	I
Ladish Co., Tri Clover Division ..	Inside Front Cover
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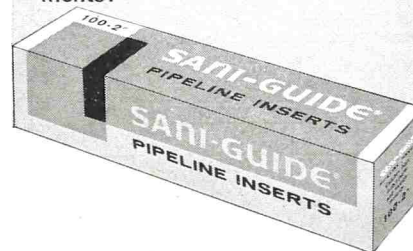
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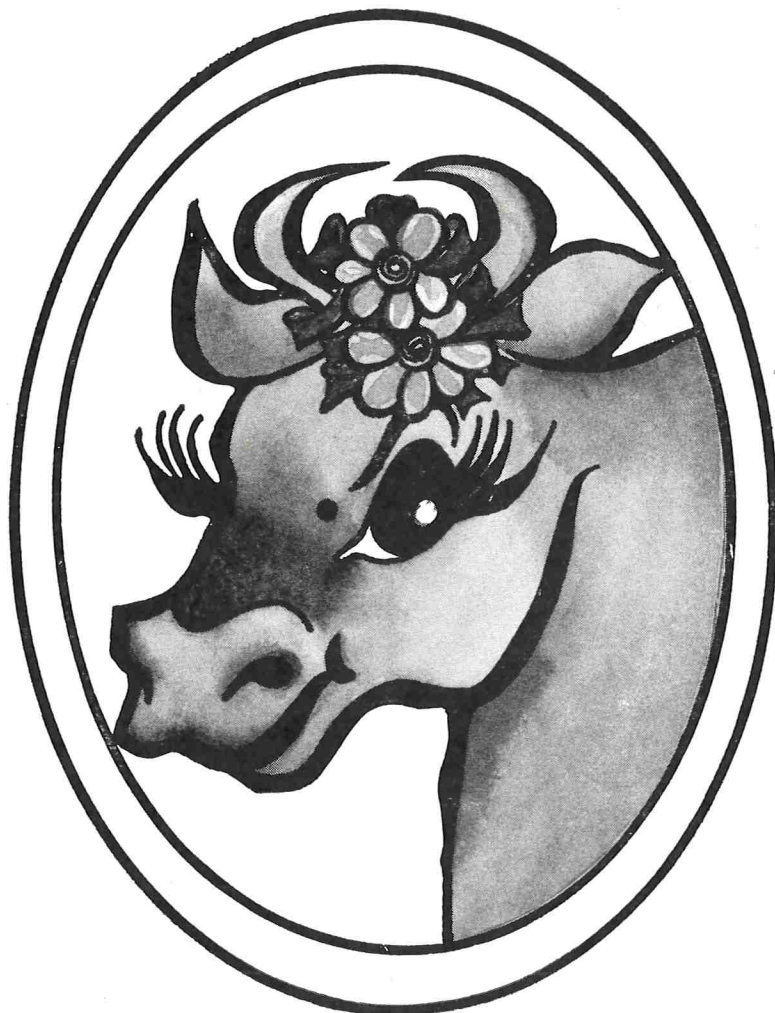
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A Surge Double-six Sawtooth Parlor is the nucleus for the new dairy installation on the Marshall Brothers' farm near Buchanan, Virginia. They changed their operation from one they described as "dawn to dusk drudgery" to a Surge Parlor, free stall set-up. They expanded their herd at the same time.

The Marshalls had been milking 75 to 80 head in two herds on separate farms in stanchion barns.

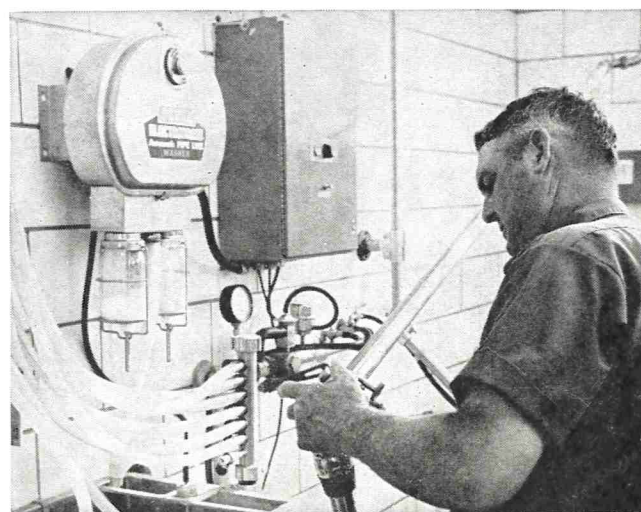
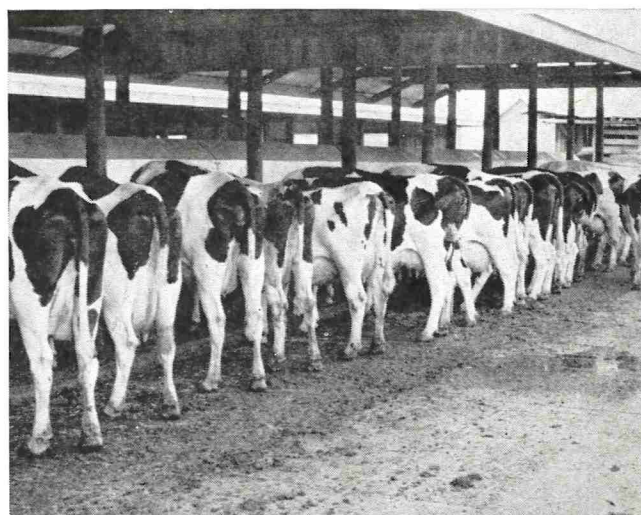
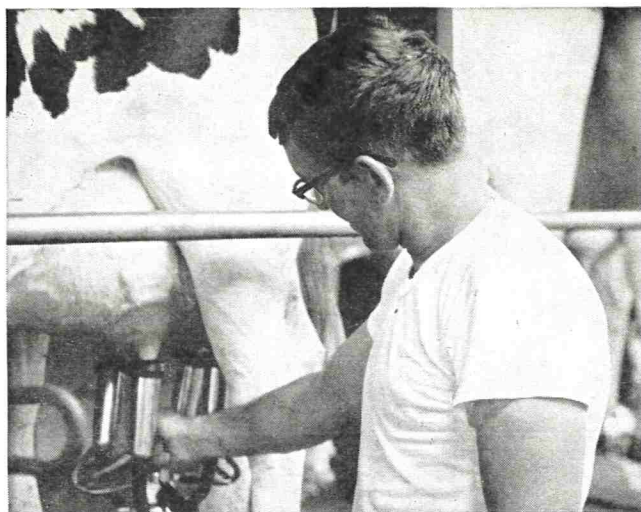
"It took all three of us plus our full time tenant just to get the milking done and we had to be out there at 5 A.M. every day," explained Eldridge Marshall.

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