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COMBINED USE OF HEAT AND RADIATION TREATMENT FOR STERILIZATION OF FOODS

Period 7 February 1956 to 7 April 1956

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Project 2391

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QUARTERMASTER FOOD AND CONTAINER INSTITUTE
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EVALUATION OF CONSECUTIVE IRRADIATION AND HEAT PROCESSING FOR STERILIZING CANNED MEAT

The data shown in Table I establish the combined heat and irradiation processing treatments required to sterilize ground beef packed in No. 1 picnic tin cans. When approximately 5,000,000 C. botulinum 213B spores are inoculated into previously heat-sterilized canned beef, the meat can again be sterilized with from 3.42 to 3.96 megarep of gamma radiation from cobalt-60 or by a heat process developing an F_0 of approximately 1.0. When heat and radiation processing are used together, preirradiation of the canned meat with less than half the sterilizing dose of gamma rays reduces the subsequent heat processing time required for

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TABLE I

F_0 Required to Sterilize Ground Beef Packed in No. 1 Picnic Tin Cans, Inoculated with C. botulinum 213B Spores and Irradiated with Gamma Rays from Cobalt-60 Before Heat Processing

Megarep	F_0 Range, Minutes	Actual Number of Spores per Can
a) 5,000,000 spores per can (approx.)		
3.42-3.96	0	5,000,000
0	0.75-1.30	7,200,000
0	Close to 1.0	10,700,000
0	0.36-0.93	10,700,000
0.500	0.77-1.06	6,000,000
0.675	More than 0.58	6,300,000
1.000	0.41-0.80	6,000,000
1.200	0.09-0.29	3,800,000
1.500	0.063-0.27	5,000,000
b) 300 spores per can (approx.)		
0	0.14-0.31	125
0	0.15-0.45	400
1.12-2.30	0	*250
0.5	Approx. 0.4 (now incubating)	300

Note: Incubation temperature for runs in Section (a) is 37°C; for those in Section (b), 29°C, except for *, which also is 37°C.

sterilization to less than one-fourth the amount required without preirradiation. These data are based on incubation of the processed cans at 37°C. The data reported in Table I(b), except for the irradiation alone, were obtained from canned beef incubated at 29°C. This incubation temperature is to be used for future work. The data in Table I further show that reducing the C. botulinum 213B spore concentration from 5,000,000 to 300 spores per can results in a corresponding reduction in the F_0 required from approximately 1.0 to approximately 0.3; similarly, the radiation sterilization dosage drops from the range of 3.42 to 3.96 megarep to 1.12 to 2.30 megarep.

It will be noted in Table I that preirradiation with about 0.9 megarep of gamma radiation is required before the combined radiation-heat process shows significant advantage. This has been established for the 5,000,000 spores per can concentration, and it now appears that this probably will be indicated for the 300 spores per can level also. Data from last year's project, obtained when gelatin was used as the suspending medium for C. botulinum 213B spores, produced this same conclusion [see Kempe, Applied Microbiology, 3:350 (1955), Fig. 5].

Table II shows the basic data, summarized in Table I, that have been accumulated during this reporting interval.

At present, work is continuing to complete the series of tests designed to establish combined irradiation and heat processing treatments required to sterilize canned ground beef containing approximately 250 C. botulinum 213B spores per can. Also, the vacuum closing machine is being readied for further studies of the combined irradiation and heat processing treatment. In this process the canned meat will be inoculated while raw. It will then be irradiated in the raw condition and finally heat processed. This will differ from the present studies in that the meat is now first sterilized with steam under pressure, then inoculated, and finally heat processed again. The difference will of course arise from any possible effects of raw-meat components on the effectiveness of the preirradiation treatment.

EFFECT OF CHEMICALS IN THE SUSPENDING MEDIUM ON THE LETHALITY OF GAMMA RADIATION FOR ANAEROBIC SPORES

Work is continuing on this phase of the project but will not be reported on at this time.

EFFECT OF TEMPERATURE OF THE SUSPENDING MEDIUM DURING IRRADIATION ON THE LETHALITY OF GAMMA RADIATION FOR ANAEROBIC BACTERIAL SPORES

During the past few weeks equipment has been designed, built, and tested to take data at temperatures above 100°C. This temperature range is important but poses several problems of technique. However, these problems appear to have been satisfactorily solved and data will be taken at temperatures above 100°C within the near future.

TABLE II

Processing Treatments Required to Sterilize Canned Ground Beef Inoculated with C. botulinum 213B Spores

Run CB-14

Objective: Establish radiation sterilization level at low spore concentration

Can size - No. 1 Picnic
Product - Ground Beef
Inoculation - 250 C. botulinum 213B spores per can
Temperature of irradiation - 6°C

Irradiation Dose, megarep	Can No.	Gas Formation	Days to Gas Formation
Inoculated Controls (from Run CB-13)	17	+	2.5
	18	+	2.5
	19	+	2.5
	20	+	2.5
Experimental Cans			
1.12	33	-	-
1.12	34	+	3
1.12	35	+	4
1.12	36	+	3
1.12	37	+	3
1.12	38	+	4
1.12	39	+	3
1.12	40	+	4
2.30	29	-	-
2.30	30	-	-
2.30	31	-	-
2.30	32	-	-
2.90	25	-	-
2.90	26	-	-
2.90	27	-	-
2.90	28	-	-
3.40	17	-	-
3.40	18	-	-
3.40	19	-	-
3.40	20	-	-
4.00	21	-	-
4.00	22	-	-
4.00	23	-	-
4.00	24	-	-

Conclusion: The radiation sterilization dosage for canned ground beef containing 250 C. botulinum 213B spores per can lies between 1.12 and 2.30 megarep of cobalt-60 gamma radiation. Note: This compares favorably with data reported previously for No. 2 cans of canned beef [see Kempe, Graikoski, and Gillis, Applied Microbiology, 2:330 (1954)].

TABLE II (Continued)

Run CB-15

Objective: Establish radiation sterilization level at high spore concentration

Can size - No. 1 Picnic
Product - Ground Beef
Inoculation - 5,000,000 C. botulinum 213B spores per can
Irradiation temperature - 7°C

Irradiation Dose, megarep	Can No.	Gas Formation	Days to Gas Formation
Noninoculated Controls	1	-	-
	2	-	-
	3	-	-
	4	-	-
Inoculated Controls	21	+	2
	22	+	2
	23	+	2
	24	+	2
3.42	1	-	-
3.42	2	+	4
3.42	3	+	4
3.42	4	+	4
3.96	5	-	-
3.96	6	-	-
3.96	7	-	-
3.96	8	-	-
2.52	9	+	4
2.52	10	+	3
2.52	11	+	3
2.52	12	+	3
2.16	13	+	2
2.16	14	+	3
2.16	15	+	3
2.16	16	+	3
2.88	17	+	4
2.88	18	+	3
2.88	19	+	5
2.88	20	+	4

Conclusion: The radiation sterilization dosage for canned ground beef containing 5,000,000 C. botulinum 213B spores per can lies between 3.42 and 3.96 megarep of cobalt-60 gamma radiation. Note: This compares favorably with data reported previously for No. 2 cans of canned beef [see Kempe, Graikoski, and Gillis, Applied Microbiology, 2:330 (1954)].

TABLE II (Continued)

Run CB-17

Objective: Establish F_0 needed, using approximately 250 C. botulinum 213B spores per can

Can size - No. 1 Picnic
Product - Ground Beef
Inoculation - 250 C. botulinum 213B spores per can

Irradiation Dose, megarep	Can No.	Gas Formation	Days to Gas Formation
Noninoculated Controls	1	-	-
	2	-	-
	3	-	-
	4	-	-
Inoculated Controls	17	3	+
	18	3	+
	19	3	+
	20	3	+
F_0 = 0.21	1	-	-
	2	-	-
	3	-	-
	4	-	-
F_0 = 0.51	5	-	-
	6	-	-
	7	-	-
	8	-	-
F_0 = 0.28	9	-	-
	10	-	-
	11	-	-
	12	-	-
F_0 = 0.37	13	-	-
	14	-	-
	15	-	-
	16	-	-

Conclusion: F_0 for 250 C. botulinum spores per can appears to be less than 0.21.

TABLE II (Continued)

Run CB-18

Objective: Establish F_0, using approximately 250 C. botulinum 213B spores per can

Can size - No. 1 Picnic
Product - Ground Beef
Inoculation - 125 C. botulinum 213B spores per can

F_0	Can No.	Days to Gas Formation	*Toxin Production
Noninoculated Controls	1	4	0/3
	2		
	3	14	0/3
	4		
Inoculated Controls	17	3	
	18	3	
	19	3	3/3
	20	3	
Can 1 = 0.31	1	7	0/3
Can 2 = 0.26	2	-	
	3	-	
	4	-	
Can 1 = 0.14	5	4	3/3
	6	4	
	7	4	0/3
	8	4	
Can 1 = 0.079	9	3	1/3
Can 2 = 0.058	10	3	1/3
	11	3	
	12	3	
Can 1 = 0.035	13	3	
	14	3	
	15	3	3/3
	16	3	

Conclusion: F_0 of 250 C. botulinum 213B spores in ground beef packed in No. 1 picnic tin cans lies between 0.14 and 0.31.

*Toxin production reported as fraction of $\frac{\text{Number of dead mice}}{\text{Number of mice inoculated}}$

Control of toxin: Heated toxin containing sample 0/3 mice.

TABLE II (Concluded)

Run CB-19

Objective: Establish F_o, using approximately 250 C. botulinum 213B spores per can

Can size - No. 1 Picnic
Product - Canned Beef
Inoculation - 400 C. botulinum 213B spores per can

F_o	Can No.	Days to Gas Formation	*Toxin Production
Inoculated Control	19	4	
	20	1	
	21	4	2/3
	22	4	
Noninoculated Control	1	17	under investigation
	2	-	
	3	-	
	4	-	
Can 1 = 0.030	1	6	
Can 2 = 0.045	2	6	
	3	4	
	4	6	
Can 1 = 0.084	5	5	
	6	4	2/3
	7	4	1/3
	8	5	
Can 1 = 0.15	9	-	
	10	-	
	11	-	
	12	8	3/3
Can 1 = 0.26	13		
0.45	14		
	15		
	16	4	0/3

Conclusion: F_o of 400 C. botulinum 213B spores per can lies between 0.15 and 0.45.