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COMBINED USE OF HEAT AND RADIATION TREATMENT FOR STERILIZATION OF FOODS

Period 1 December 1956 to 31 January 1957

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Project 2391

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Official Investigator: Lloyd L. Kempe
Collaborator: J. T. Graikoski

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SUMMARY

Tests of the combined irradiation-heat processing of previously heated canned ground beef inoculated with 10,000 PA-3679 spores per No. 1 picnic tin can are complete except as they may be modified by late incubation deviations. Present data indicate the following:

1. Approximately 1.0 megarep preirradiation reduces the F_o subsequently required to sterilize canned ground beef to about half that required without irradiation. Specifically, the F_o required to produce sterility was reduced from a value of approximately 8 without preirradiation to 4.2 following 1.0 megarep of gamma irradiation.

2. Approximately 1.8 megarep preirradiation were required to reduce the F_o required for sterility to a value of 1.0.

EFFECT OF PREIRRADIATION OF CANNED GROUND BEEF INOCULATED WITH PA-3679 SPORES ON THE F_o SUBSEQUENTLY REQUIRED FOR STERILIZATION

Sterilization of canned meat by ionizing radiations requires high dosages to be certain of producing a safe product because C. botulinum spores are among the most resistant of the anaerobic bacterial species to irradiation. Extrapolation of our previous data indicates that irradiation dosages of five or six megarep may be necessary for this purpose.[1] However, C. botulinum spores are quite sensitive to heat, so combined heat and irradiation processes are quite effective in sterilizing meat containing these spores. This has been previously indicated in the Annual Report of this project for 1956 in which it was shown that ground beef containing 5,000,000 C. botulinum spores per can was sterilized by an F_o of 0.2 following irradiation with 1.2 megarep of gamma rays. The present work is concerned with combined irradiation-heat processing of ground beef in No. 1 picnic tin cans inoculated with 10,000 PA-3679 spores per can

The techniques in use have been previously discussed in the 1956 Annual Report and in Progress Report No. 9 of this project. It was found necessary to correct some of the radiation dosages reported for runs discussed in Progress Report No. 9, using calibration data obtained Jan. 7, 1957. Delayed germinations are also occurring; some as late as two months have been observed. Where these have been found, the data have been corrected. Obviously, final results must be even further delayed because of this factor.

Table I includes data from runs 18 through 25, all of which were carried out under similar conditions as indicated. Results from these runs, along with previously acquired data that have been corrected as indicated above, are summarized in Table II. Data from Table II are plotted in the accompanying figure and indicate the following for inoculated packs treated as designated:

Can size: No. 1 picnic (211 x 400)
Product: Ground beef
Inoculum: 10,000 PA-3679 spores per can
Preirradiation: As indicated
Processing temperature: 230°F
Incubation temperature: 29°C

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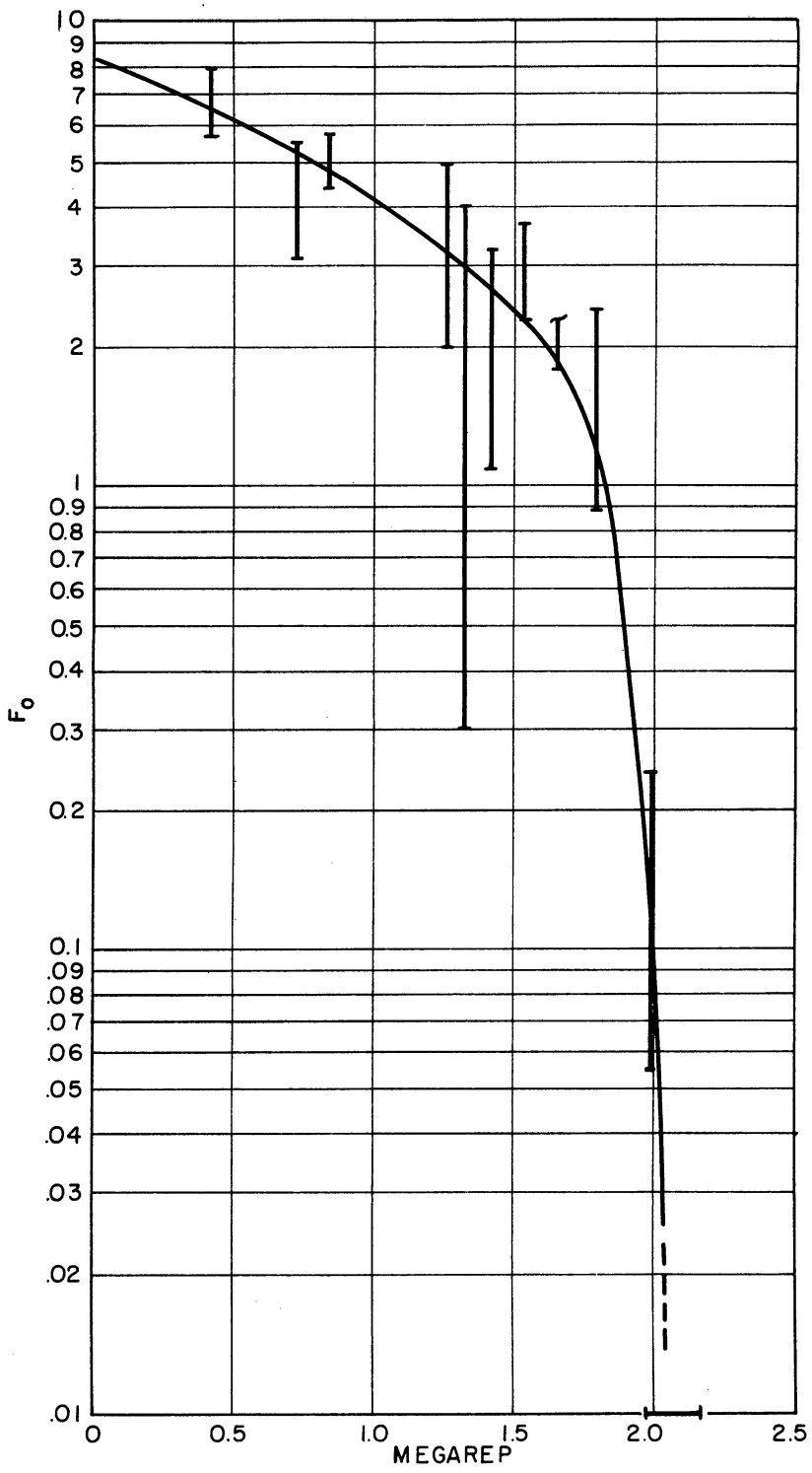
[1] "Gamma-ray sterilization of canned meat previously inoculated with anaerobic bacterial spores." Kempe et al. Applied Microbiology, 2, 330 (1954).

Without irradiation, an F_0 of approximately 8 was required to sterilize the canned beef; with irradiation alone, between 1.970 and 2.160 megarep were required for this purpose. Preirradiation with 1.0 megarep of gamma radiation reduced the F_0 required to produce sterility to 4.2; further reduction to an F_0 of 1.0 was obtained by preirradiation with approximately 1.85 megarep.

Some interesting considerations are developing from this project. Sterilization of foods with ionizing radiations alone will likely require very high dosages because C. botulinum spores are very resistant to radiation. This contrasts with their relatively low heat resistance. Combined irradiation-heat processing of canned foods restores the desirable processing resistance-relationship between C. botulinum and putrefactive anaerobe spores, viz.: the latter are more resistant to combined processing than the former. Therefore, when a combined processing treatment is designed to sterilize canned meat containing PA-3679 spores, it will provide an inherent safety factor insofar as C. botulinum spores are concerned. The number of spores present in the canned food initially seem to have only limited effect on the severity of the combined processing treatment required.

At present, runs similar to those discussed in this report are being conducted except that 300 PA-3679 spores are being used per can instead of 10,000. Exploratory runs are also being made with inoculated packs of fresh meat which are first irradiated and then heat-processed.



F_o required to sterilize ground beef packed in No. 1 picnic tin cans, inoculated with 10,000 PA-3679 spores per can, and irradiated with gamma rays from cobalt-60 before heat processing at 230°F.

TABLE I. F_o Value Required to Sterilize Ground Beef in No. 1 Picnic Tin Cans, Previously Inoculated with 10,000 PA-2679 Spores per Can and Irradiated with Gamma Rays from Cobalt-60 Before Processing at 230°F.

Run No. PA-18—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 1.652 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Inoculated Controls	1	4
	2	4
	3	4
	4	4
Can 1, 1.1	1	-
Can 2, 1.1	2	-
Can 3, 0.68	3	-
	4	-
Can 1, 1.8	5	-
Can 2, 1.8	6	-
	7	-
	8	13
Can 1, 0.16	9	5
Can 2, 0.16	10	5
Can 3, 0.10	11	6
	12	-
Can 1, 0.57	13	5
Can 2, 0.40	14	-
Can 3, 0.25	15	-
	16	5
Can 1, 0.27	17	6
Can 2, 0.27	18	-
Can 3, 0.27	19	8
	20	4

Conclusion: Under these conditions canned ground beef was not sterilized by 1.652 megarep of gamma radiation followed by heat processing to an F_o of 1.8.

TABLE I (Continued)

Run No. PA-19—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Irradiation only
Incubation temperature - 29°C

Megarep	Can No.	Days to Gas Formation
Inoculated Controls	1	4
	2	4
Noninoculated controls		See run PA-20
1.560	13	4
	14	4
	15	4
	16	5
1.970	9	-
	10	7
	11	-
	12	-
2.625	1	-
	2	-
	3	-
	4	-
3.040	5	-
	6	-
	7	-
	8	-

Conclusion: Canned ground beef was sterilized under these conditions by 1.970 to 2.625 megarep of gamma radiation.

TABLE I (Continued)

Run No. PA-20—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 0.410 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Noninoculated Controls	1	-
	2	-
	3	-
	4	-
Inoculated Controls	See run PA-19	
Can 1, 7.9	1	-
Can 2, 7.9	2	-
	3	-
	4	-
Can 1, 4.5	5	40
Can 2, 4.5	6	-
	7	23
	8	13
Can 1, 6.1	9	6
Can 2, 6.1	10	17
Can 3, 5.7	11	-
	12	6
Can 1, 3.1	13	6
Can 2, 3.1	14	7
Can 3, 3.1	15	-
	16	5

Conclusion: Under these conditions, canned ground beef was sterilized by 0.410 megarep of gamma radiation followed by heat processing with an F_o between 5.7 and 7.9.

TABLE I (Continued)

Run No. PA-21—Can size - No. 1 picnic (211 x 400)
Product - Canned ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 1.313 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Controls	See run PA-19	
Can 1, 0.44	1	4
Can 2, 0.34	2	3
Can 3, 0.29	4	3
	8	3
Can 1, 6.6	5	-
Can 2, 6.6	6	-
Can 3, 6.0	3	-
	7	-
Can 1, 4.0	9	-
Can 2, 4.0	10	-
Can 3, 4.0	11	-
	12	-

Conclusion: Under these conditions, canned ground beef was sterilized by 1.313 megarep of gamma radiation followed by an F_o between 0.29 and 4.0.

TABLE I (Continued)

Run No. PA-22—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 1.780 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Noninoculated Controls	1	-
	2	-
	3	-
	4	-
Inoculated Controls	1	3
	2	3
	3	3
	4	3
Can 1, 2.4	1	-
Can 2, 2.1	2	-
Can 3, 1.9	3	-
	4	-
Can 1, 1.5	5	-
Can 2, 0.97	6	-
Can 3, 0.78	7	8
	8	-
Can 1, 0.56	9	4
Can 2, 0.56	10	4
	11	4
	12	6
Can 1, 0.23	13	3
Can 2, 0.20	14	4
Can 3, 0.20	15	4
	16	5

Conclusion: Under these conditions, canned ground beef was sterilized by 1.780 megarep of gamma radiation followed by an F_o between 0.78 and 2.4.

TABLE I (Continued)

Run No. PA-23—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 1.538 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Controls		See run PA-22
Can 1, 2.3	1	4
Can 2, 2.3	2	-
Can 3, 2.3	3	-
	4	-
Can 1, 1.1	5	4
Can 2, 0.97	6	4
Can 3, 0.97	7	-
	8	-
Can 1, 0.14	9	3
Can 2, 0.14	10	3
Can 3, 0.16	11	3
	12	3
Can 1, 3.1	13	-
Can 2, 3.7	14	-
Can 3, 3.4	15	-
	16	-
Can 1, 4.2	17	-
Can 2, 4.1	18	-
Can 3, 3.8	19	-
	20	-

Conclusion: Under these conditions, canned ground beef was sterilized by 1.538 megarep of gamma radiation followed by an F_o between 2.3 and 3.7.

TABLE I (Continued)

Run No. PA-24—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Preirradiation - 1.985 megarep
Processing temperature - 230°F
Incubation temperature - 29°C

F_o	Can No.	Days to Gas Formation
Noninoculated Controls	1	-
	2	-
Inoculated Controls	1	3
	2	3
	3	3
	4	3
Can 1, 0.25	1	-
Can 2, 0.23	2	-
Can 3, 0.22	3	-
	4	-
Can 1, 0.061	5	-
Can 2, 0.055	6	4
Can 3, 0.068	7	-
	8	-
Can 1, 1.61	9	-
Can 2, 1.40	10	-
Can 3, 1.32	11	-
	12	-
Can 1, 0.63	13	-
Can 2, 0.49	14	-
Can 3, 0.41	15	-
	16	-

Conclusion: Under these conditions, canned ground beef was sterilized by 1.985 megarep of gamma radiation followed by an F_o between 0.055 and 0.25.

TABLE I (Concluded)

Run No. PA-25—Can size - No. 1 picnic (211 x 400)
Product - Ground beef
Inoculum - 10,000 PA-3679 spores per can
Irradiation only
Incubation temperature - 29°C

Megarep	Can No.	Days to Gas Formation
Controls	See run PA-24	
1.620	1	4
	4	3
	5	3
	8	3
2.160	2	-
	3	-
	6	-
	7	-
2.440	9	-
	10	-
	11	-
	12	-
	13	-
	14	-

Conclusion: Under these conditions, canned ground beef was sterilized by 1.620 to 2.160 megarep of gamma radiation.

Table II. Summary of Various Combined Irradiation Heat-Processing Treatments Required to Sterilize Ground Beef in No. 1 Picnic Tin Cans Previously Inoculated with 10,000 PA-3679 Spores per Can and then Processed at 230°F.

Run No.	Preirradiation, megarep*	F_o Range, minute
10	0	> 6.0
11	1.261	2.0-4.9
12	0	> 5.8
13	0.841	4.4-5.7
14	1.420	1.1-3.2
15	0	6.5-8.4
16	0	7.1-8.7
17	0.708	3.1-5.5
18	1.652	> 1.80
19	1.970-2.625	0
20	0.410	5.7-7.9
21	1.313	0.29-4.0
22	1.780	0.78-2.4
23	1.538	2.3-3.7
24	1.985	0.055-0.25
25	1.620-2.160	0

*Note: corrected on basis of source recalibration, 1-7-57