

## SORBIC ACID INHIBITION OF CLOSTRIDIUM BOTULINUM IN NITRITE-FREE POULTRY FRANKFURTERS

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### ABSTRACT

Chicken and turkey frankfurter emulsions and ground commercial frankfurters were treated with sorbic acid or potassium sorbate together with several acidulating agents. These were inoculated with 400 spores/g of a mixture of 21 strains of *C. botulinum* (12 of type A, 9 of type B) and canned under vacuum in 208 x 107 aluminum tab cans. The cans were temperature abused at 30°C. Chicken emulsions with sodium acid pyrophosphate (used for commercial frankfurters) showed can swelling in 2 days; turkey emulsion cans swelled in 4 days. The mean swell times for chicken and turkey were, respectively: 7 and 15 days with 0.52% potassium sorbate and 13 and 35 days with 0.40% sorbic acid. Acidification of emulsions with H<sub>2</sub>PO<sub>4</sub> or glucono-δ-lactone to a pH as low as 5.4 did not increase the mean swell times; however, in combination with 0.4% sorbic acid the mean swell times were increased over those of the sorbic acid alone. Citric acid increased mean swell times in turkey but not in chicken emulsions. For poultry emulsions and poultry frankfurters commercially prepared with 0.2% sorbic acid, acidification with H<sub>2</sub>PO<sub>4</sub> to pH 5.7 resulted in appreciable increases in mean swell times; 0.4% sorbic acid without H<sub>2</sub>PO<sub>4</sub> was more effective. Indigenous microflora, causing gas production in the cans, were also inhibited by 0.4% sorbic acid and by H<sub>2</sub>PO<sub>4</sub>-acidified 0.2% sorbic acid. Finished frankfurters generally behaved the same as the emulsions in *C. botulinum* inhibition; however, they gave better protection than the emulsions when both were treated with 0.2% sorbic acid plus H<sub>2</sub>PO<sub>4</sub>.

### INTRODUCTION

SORBIC ACID has been recognized as an effective fungistatic agent for foods since 1945 (Gooding, 1945). Its lack of toxicity for mammals was demonstrated by Deuel et al. (1954a). It appears to be metabolized by mammals in the same way caproic acid is (Deuel et al., 1954b). Emard and Vaughn (1952) indicated that sorbic acid could be used for the selective growth of lactic acid bacteria from mixed culture. Hansen and Appleman (1955) indicated that sorbic acid was an effective inhibitor of gram negative bacteria but was ineffective against *Clostridium sporogenes* or *C. botulinum* in culture media at pH 6.7. York and Vaughn (1954) found many species of clostridia to be resistant to sorbic acid in culture media at pH 6.8. They also found (1955) that *C. botulinum* types A and B were resistant to 0.12% sorbic acid even at pH 5.0 or below.

In meat products, on the other hand, Tompkin et al. (1974) found potassium sorbate to be effective against *C. botulinum* in cooked, uncured sausage. Ivey et al. (1978) reported a prolongation of toxicogenesis from *C. botulinum* in potassium sorbate treated bacon, while Ivey and Robach (1978) found it to be effective against this organism in canned comminuted pork. Sofos et al. (1979a, b) demonstrated the effectiveness of a combination of sorbic acid and nitrite in preventing toxin production by *C. botulinum* in chicken frankfurter emulsions.

The work reported here was done to compare sorbic acid-treated poultry emulsions with finished frankfurters with respect to their ability to sustain growth of and toxin production by *C. botulinum*.

Table 1—Types and origins of *C. botulinum* strains in spore suspensions

Number	Type	Origin
2 OPLALCA	A	CDC (Center for Disease Control, Atlanta)
174091 A	A	CDC (Center for Disease Control, Atlanta)
3	A	FSQS (Food Safety and Quality Service, USDA)
4	A	FSQS (Food Safety and Quality Service, USDA)
33A	A	Natick (Natick Research and Development Command)
81218	A	NRRC (Northern Regional Research Center, USDA)
25763	A	ATCC (American Type Culture Collection)
62	A	FDA (Food & Drug Administration)
69	A	FDA (Food & Drug Administration)
78	A	FDA (Food & Drug Administration)
426	A	FDA (Food & Drug Administration)
429	A	FDA (Food & Drug Administration)
169	B	FDA (Food & Drug Administration)
383	B	FDA (Food & Drug Administration)
642	B	FDA (Food & Drug Administration)
999	B	FDA (Food & Drug Administration)
8688R	B	FDA (Food & Drug Administration)
5	B	FSQS (Food Safety & Quality Service, USDA)
770B	B	FSQS (Food Safety & Quality Service, USDA)
53 B	B	Natick (Natick Research & Development Command)
7949	B	ATCC (American Type Culture Collection)

### EXPERIMENTAL

#### Emulsions

Poultry emulsions were obtained from Horace W. Longacre, Inc. (Franconia, Pa.) through the courtesy of Dr. J. Bauermann. These were kept refrigerated and used within 24 hr of preparation. Two-hundred pound batches were made with appropriate seasoning and 550 ppm erythorbate; all other additions were made in the laboratory. The chicken meat was mostly mechanically deboned necks, while the turkey-meat was mechanically deboned racks (backs, ribcages, and breasts) and skins.

#### Frankfurters

The poultry frankfurters were prepared at Medfords, Inc. (Chester, Pa.) from 200 lb. batches of emulsions. They were processed with a mixture of natural and artificial smoke with the internal temperature of the frankfurters reaching 160–164°F in a period of about 50 min. The total process, including brine chilling, required about 2 hr. The frankfurters were peeled and packaged under vacuum in plastic.

#### Spores

Twenty-one strains of *C. botulinum* were used, 12 of type A and 9 of type B (see Table 1 for their origin). Spore suspensions were made by centrifuging and washing cultures grown for 2 wk at 30°C in brain heart infusion broth supplemented with 5% tryptone and 0.1% sodium thioglycollate. Spore suspensions were made up in water and heat shocked at 68–70°C for 30 min, and refrigerated. Most probable number counts were made in fluid thioglycollate broth incubated at 30°C for 1 wk in an anaerobic incubator (National Appliance Co.) that was evacuated to 25 in. vacuum with nitrogen replacement. After counts were obtained for the individual suspensions, a mixture of all spores was made, giving an equal concentration of each for a total of  $2.1 \times 10^5$  per ml.

#### Experimental preparations

Emulsions for laboratory experiments were 800g batches with

all additives and spores mixed in by hand. These were packed in 70-75g amounts into 208 x 107 aluminum tab cans, sealed under 20 in. vacuum in a Rooney canner, heated to an internal temperature of 68-70°C with a 30 min holding time, and incubated at 30°C for 60 days or until swelling occurred. Frankfurters were ground three times through a 1/8-in. plate and treated as above.

#### Toxin testing

Selected samples of swollen cans (usually the first and second cans or those showing prolonged swell times) and all nonswollen cans were assayed for toxins. Two volumes of gelatin phosphate buffer were added to the can contents and after standing overnight in a refrigerator, these were centrifuged, and 0.5 ml of the supernatant was injected into each of two mice. Positive samples caused typical signs of botulism, followed in nearly all cases by death. When death did not occur, the extracted samples were again injected into mice and symptoms of botulism were observed. When atypical

deaths occurred, protective antisera (A and B) verified that death was caused by botulinal toxin.

#### pH Measurements

One to two volumes of water were added to emulsions or to ground frankfurters. This was gently mixed with a spatula and kept at room temperature for 2-3 hr. Measurements were made with a combination electrode in a digital meter sensitive to the second decimal point. Readings were rounded off to the first decimal point.

### RESULTS

A PRELIMINARY EXPERIMENT with noninoculated emulsions containing sodium acid polyphosphate (Table 2) indicated that the cans of control chicken emulsions swelled in 2 days. With potassium sorbate at 0.26 or 0.52% this was extended to a mean swell time (MST) of 6 or 7

Table 2—Outgrowth of *C. botulinum* in poultry emulsions with sorbic acid and potassium sorbate

Additions <sup>a</sup>	pH	Not inoculated			Inoculated		
		Mean swell time (days)	Range	No. cans swollen/no. tested	Mean swell time (days)	Range	No. cans swollen/no. tested
<b>Chicken</b>							
none	6.6	2	2-3	5/5	3	2-3	5/5
0.26% Potassium sorbate	6.7	6	5-6	5/5	5	3-5	5/5
0.52% Potassium sorbate	6.7	7	5-7	5/5	5	5	5/5
0.20% Sorbic acid	6.2	5	5	5/5	6	5-6	5/5
0.40% Sorbic acid	6.0	13	8-21	5/5	26	13-35	3/5
<b>Turkey</b>							
none	6.4	4	2-5	5/5	3	2-3	5/5
0.26% Potassium sorbate	6.4	8	5-10	5/5	5	3-5	5/5
0.52% Potassium sorbate	6.5	15	12-24	5/5	9	8-10	5/5
0.20% Sorbic acid	6.2	10	9-12	4/5	6	5-8	5/5
0.40% Sorbic acid	6.1	35	15-71	3/5	52	34-71	2/5

<sup>a</sup> Basic mix for chicken emulsions consisted of 2.2% NaCl, 0.21% sodium acid polyphosphate, and 550 ppm erythorbate; for turkey it was 2.2% NaCl, 0.5% sodium acid polyphosphate, 550 ppm erythorbate, and 7.5% H<sub>2</sub>O.

Table 3—Outgrowth of *C. botulinum* in poultry emulsions with sorbic acid and acidulants

	Additions <sup>a</sup>				pH	Mean swell time (days)	Range	No. cans swollen/no. tested	No. cans emulsion toxic/no. tested
	Sorbic acid %	H <sub>3</sub> PO <sub>4</sub> % (w/w)	Sodium acid pyrophosphate %	Glucono-δ-lactone %					
<b>Chicken</b>									
	—	—	—	—	6.7	4	4	5/5	—
	0.4	—	—	—	5.9	15	9-24	5/5	2/2
	—	0.18	—	—	5.4	4	4	5/5	—
	—	—	0.21	—	6.6	4	4	5/5	—
	—	—	—	0.6	6.4	4	4-5	5/5	—
	0.4	0.18	—	—	5.7	50	50	1/5	0/5
	0.4	—	0.21	—	6.2	23	12-57	5/5	—
	0.4	—	—	0.6	5.8	>60	—	0/5	0/5
	0.4	0.18	—	0.6	6.0	>60	—	0/5	—
	0.4	—	0.21	0.6	5.4	>60	—	0/5	—
<b>Turkey</b>									
	—	—	—	—	6.4	4	4-6	5/5	—
	0.4	—	—	—	6.0	54	47-60	2/5	2/2
	—	0.18	—	—	5.6	10	4-13	5/5	2/2
	—	—	0.50	—	6.4	5	5	5/5	—
	—	—	—	0.6	5.7	6	5-6	5/5	2/2
	0.4	0.18	—	—	5.7	>60	—	0/5	0/2
	0.4	—	0.50	—	6.0	54	54	1/5	1/2
	0.4	—	—	0.6	5.6	>60	—	0/5	—
	0.4	0.18	—	0.6	4.8	>60	—	0/5	—
	0.4	—	0.50	0.6	5.4	>60	—	0/5	—

<sup>a</sup> Basic mix for chicken emulsions was 2.2% NaCl, chicken seasoning, and 550 ppm erythorbate; for turkey it was 2.2% NaCl, turkey seasoning, 550 ppm erythorbate, and 7.5% H<sub>2</sub>O.

days, while with 0.20 or 0.40% sorbic acid the MST was 5 and 13 days, respectively. When emulsions were inoculated with the spores, the swell times were about the same; however, of the inoculated swollen cans that were tested all were positive for toxin, while none of the tested noninoculated cans was positive. Unheated uninoculated cans of chicken emulsion swelled in 16–24 hr. Culturing of the emulsion on SPS agar indicated that the can swelling was caused by *C. perfringens*. The isolated black colonies from SPS plates were nonmotile, fermented lactose, and hydrolyzed gelatin.

Turkey emulsions behaved in a similar manner, though usually showing longer mean swell times. All inoculated emulsions in swelled cans were toxic and, as with chicken emulsions, the noninoculated emulsions in swollen cans were nontoxic. Sorbic acid at 0.40% produced a lower pH

and was more effective in both poultry emulsions than was the equivalent amount of 0.52% potassium sorbate.

Acidification to pH 5.4 with  $H_3PO_4$  did not prolong the MST of chicken emulsions (Table 3), but acidification to pH 5.6 did lengthen the MST of turkey emulsions. Addition of 0.6% glucono- $\delta$ -lactone (GDL) gave a pH of 6.4 in chicken emulsions, with no increase in MST and in turkey emulsions a pH of 5.7 with slight increase in MST. Addition of sodium acid pyrophosphate alone had no effect in either emulsion. Sorbic acid at 0.4% increased the MST of chicken emulsions from 4 days for the controls to 15 days and in turkey emulsions, from 4 days for the controls to 54 days, with 2/5 cans swelling (these were both toxic). Addition of  $H_3PO_4$  and 0.4% sorbic acid resulted in a pH of 5.7 in the chicken emulsions and only one can of a total of five tested swelled in the same period. This combination lowered the

Table 4—Inhibition of outgrowth of *C. botulinum* in emulsions by sorbic, phosphoric, and citric acids

	Additions <sup>a</sup>			pH <sup>a</sup>	Swell time <sup>b</sup> (days)		No. cans swollen/ no. tested	No. cans emulsion toxic/no. cans tested	
	Sorbic acid %	$H_3PO_4$ <sup>c</sup> % (w/w)	Citric acid %		Mean	Range		Swollen	Nonswollen
Expt. 1	—	—	—	6.6	3	3	9/9	2/2	—
Chicken	0.4	—	—	5.8	23	12–28	7/9	3/3	—
	0.4	0.04	—	5.6	>31	—	0/9	—	0/5
Expt. 2	—	—	—	6.6	3	3	9/9	2/2	—
Chicken	0.4	—	—	6.1	19	13–28	7/9	2/2	0/2
	0.4	—	0.07	5.6	19	12–23	5/9	4/4	2/3
Expt. 1	—	—	—	5.7	3	3–5	9/9	2/2	—
Turkey	0.4	—	—	5.7	13	7–31	8/9	3/3	—
	0.4	0.01	—	5.5	25	25	1/9	—	0/4
Expt. 2	—	—	—	6.2	3	3	9/9	2/2	—
Turkey	0.4	—	—	5.7	21	21	1/9	—	1/4
	0.4	—	0.01	5.6	>60	—	0/9	—	0/5

<sup>a</sup> Basic mix for chicken was 2.2% NaCl, chicken seasoning, and 550 ppm erythorbate; for turkey it was 2.2% NaCl, turkey seasoning, 550 ppm erythorbate, and 7.5%  $H_2O$ .

<sup>b</sup> Cans for Expt. 1 incubated at 30° C for 31 days or until swollen; for Expt. 2 incubation was 60 days.

<sup>c</sup> The amounts of acidulant added were determined by titration to give final pH's around 5.7–5.9.

Table 5—Outgrowth of *C. botulinum* in commercially prepared chicken and turkey emulsions and frankfurters containing sorbic and phosphoric acids

Additions <sup>a</sup>	Chicken					Turkey				
	pH	Mean <sup>b</sup> swell time (days)	Range	No. cans swollen/ no. tested	No. cans toxic/ no. tested	pH	Mean <sup>b</sup> swell time (days)	Range	No. cans swollen/ no. tested	No. cans toxic/ no. tested
Emulsions										
0.2% Sorbic acid	6.2	4	4–5	10/10	2/2	5.9	7	6–8	10/10	2/2
0.4% Sorbic acid	5.9	25	21–32	4/10	2/4 (0/6) <sup>c</sup>	5.6	>60	—	0/10	0/10
0.2% Sorbic acid + $H_3PO_4$	5.8	12	11–15	10/10	2/2	5.7	13	11–18	9/10	2/2
Controls <sup>d</sup>	6.3	5	5–6	10/10	2/2	6.1	30	21–36	5/10	6/10 (1/5) <sup>c</sup>
Frankfurters										
0.2% Sorbic acid	6.0	7	7–8	5/5	—	5.7	14	14–15	5/5	—
0.4% Sorbic acid	5.7	21	19–24	5/5	—	5.5	>60	—	0/5	—
0.2% Sorbic acid + $H_3PO_4$	5.6	23	19–27	5/5	—	5.6	35	32–38	5/5	—
Controls <sup>d</sup>	5.7	15	14–16	5/5	—	5.7	29	28–30	5/5	—

<sup>a</sup> Emulsions prepared in 200-lb batches. To these were added sorbic acid, 2.2% NaCl, seasoning, and 550 ppm erythorbate. To turkey emulsions, 7.5%  $H_2O$  was added.  $H_3PO_4$  added at 0.2% level to chicken and 0.1% level to turkey emulsions. Frankfurters were ground three times through a 1/8 in. sieve.

<sup>b</sup> Cans incubated to 60 days or until swelling occurred.

<sup>c</sup> These were nonswollen cans tested for toxin.

<sup>d</sup> The controls were emulsions of commerce and also contained sodium acid polyphosphate (0.21% for chicken emulsions and 0.50% for turkey) plus 135 ppm  $NaNO_2$ .

Table 6—Can swelling by indigenous microflora of poultry emulsions and frankfurters

Additions <sup>a</sup>	Chicken			Turkey		
	Mean swell time (days)	Range	No. cans swollen/ no. tested	Mean swell time (days)	Range	No. cans swollen/ no. tested
<b>Emulsions</b>						
0.2% Sorbic acid	5	5	4/4	9	10–15	3/4
0.4% Sorbic acid	15	13–18	4/4	>60	—	0/4
0.2% Sorbic acid + H <sub>3</sub> PO <sub>4</sub>	16	12–18	4/4	27	5–40	4/4
Control	12	6–18	4/4	>60	—	0/4
<b>Frankfurters</b>						
0.2% Sorbic acid	7	7–8	5/5	38	29–50	4/5
0.4% Sorbic acid	37	21–55	5/5	>60	—	0/5
0.2% Sorbic acid + H <sub>3</sub> PO <sub>4</sub>	27	19–31	5/5	83	75–92	2/5
Control	29	28–30	2/5	57	37–77	2/5

<sup>a</sup> See footnotes, Table 5.

pH to 5.7 in turkey emulsions; no cans swelled in 60 days. Glucono- $\delta$ -lactone with sorbic acid gave a pH of 5.8 in chicken emulsions and a pH of 4.8 in turkey emulsions, with no swollen cans or toxicity in either in 60 days.

Citric acid was compared with H<sub>3</sub>PO<sub>4</sub> as an acidulant (Table 4). Prior to the experiment, the emulsions with sorbic acid were titrated with the two acids to a pH of 5.7; appropriate amounts were then added to the experimental preparations. The control pH for both chicken emulsions was 6.6; with the citric acid or H<sub>3</sub>PO<sub>4</sub> this decreased to 5.6. No cans of chicken emulsion with H<sub>3</sub>PO<sub>4</sub> swelled in 1 month while all cans with citric acid swelled within this period; the MST was 19 days. In the turkey emulsion, no accurate comparison of the two acids was possible since only one can swelled; the content of this can was nontoxic.

Emulsions and frankfurters were made with 0.2% or 0.4% sorbic acid, or with 0.2% sorbic acid acidified with H<sub>3</sub>PO<sub>4</sub>. These were compared to emulsions containing 135 ppm NaNO<sub>2</sub> currently used for making commercial frankfurters. The results are presented in Table 5. Prior experiments had indicated that 0.2% H<sub>3</sub>PO<sub>4</sub> in chicken emulsions or 0.1% in turkey emulsions was sufficient to reach a target pH of 5.7. The commercial chicken emulsions containing 0.2% sorbic acid had a pH of 6.2 and a MST of 4 days; with 0.4% sorbic acid the pH was 5.9 with a MST of 25 days. Chicken emulsion containing 0.2% sorbic acid plus 0.2% H<sub>3</sub>PO<sub>4</sub> had a pH of 5.8 with a 12-day MST. By comparison, the controls, containing sodium acid polyphosphate and 135 ppm nitrite, had a pH of 6.3 with a MST of 5 days. The finished chicken frankfurters with sorbic acid had pH's about 0.2 units lower than the emulsions. Those prepared with nitrite were 0.6 units lower. The acidified 0.2% sorbic acid frankfurters showed an increase in MST over that of the emulsions (23 vs 12 days).

Turkey emulsions (Table 5) had lower pH's in all treatments than the chicken emulsions, and with all treatments except the acidified 0.2% sorbic acid, gave longer MST's in the cans. The MST of finished turkey frankfurters with 0.2% sorbic acid, with and without acidification, was twice that of the chicken frankfurters. The nitrite-containing control emulsions and frankfurters of commerce had MST's considerably longer than those treated with 0.2% sorbic acid.

The indigenous microflora of chicken and turkey emulsions and frankfurters were inhibited by some of the sorbic acid treatments (Table 6). The most effective treatment in the turkey emulsions and turkey frankfurters was 0.4% sorbic acid. This was also effective in the chicken emulsions and frankfurters but it was of the same order of activity as

the acidified 0.2% products and the controls with 135 ppm nitrite.

The indigenous gas producing microflora of the turkey emulsions and frankfurters produced longer MST's in all cases than the chicken emulsions and frankfurters. As with the chicken, the turkey frankfurters had longer MST's than the emulsions from which they were made.

## DISCUSSION

FROM THE WORK of Sofos et al. (1979a, b) and our observations reported here, it appears that sorbic acid can be used to inhibit *C. botulinum* spore outgrowth in poultry frankfurters. Some differences were apparent in the two studies. Sofos et al. (1979b) working with frozen chicken emulsions, found that the time before toxin was evident increased from 4 days for controls to 7 days with 0.2% sorbic acid. Our results with chicken emulsions showed increases in the mean swell times and concurrent toxin production, from 2 days for controls to 5 days with 0.2% sorbic acid treatment; with turkey emulsions the increase was from 4 days for controls to 10 days with 0.2% sorbic acid. It is possible that the differences in the chicken emulsions may have been due to differences in emulsions (frozen vs fresh) or in technique. Sofos and co-workers used toxin production as the sole criterion for *C. botulinum* outgrowth, while we first observed gas production and then assayed swollen cans for toxin.

The lower pH and the greater efficacy of sorbic acid over potassium sorbate indicate that the undissociated acid is responsible for the inhibition of outgrowth of *C. botulinum* spores. This was further borne out by the increases in mean swell times and toxin production when 0.4% sorbic acid-treated chicken emulsions were acidified with phosphoric acid. Phosphoric acid alone, at the same pH, had no effect on the mean swell times.

The importance of a low pH for obtaining maximum inhibition of microorganisms by sorbic acid was emphasized by Emard and Vaughn (1952) in their work on sorbic acid inhibition of gram negative bacteria. York and Vaughn (1954) indicated that the limiting pH for spore germination was not appreciably influenced by 0.12% sorbic acid in a liver infusion medium; they found, however, that different species of *Clostridium* had markedly different limiting pH's for spore germination. They recommended a pH greater than 6.0 for allowing growth of clostridia in the presence of other organisms in a medium with 0.12% sorbic acid. The same authors (York and Vaughn, 1955) later showed that *C. botulinum* (types C, D, and E) and *C. parabotulinum* (*C. botulinum* types A and B) grew in liver infusion broth at

pH 5.6 in the presence of 0.12% sorbic acid. In the light of the apparent non-inhibition of clostridia in test tube experiments, it is remarkable that sorbic acid is effective in meat systems as shown by Ivey and Robach (1978) for pork, Ivey et al. (1978) for bacon, Tompkin et al. (1974) for sausage, Sofos et al. (1979a, b) for chicken, as well as our own work with chicken and turkey emulsions and frankfurters.

At the present time we have no explanation for our turkey emulsions and frankfurters (as well as those commercially prepared with nitrite) showing longer mean swell times and toxin production times than the chicken emulsions and frankfurters. Bauermann and Honeywell (1979) found differences in the iron content of the emulsions, with the chicken emulsions containing about twice as much as the turkey; the chicken emulsions also had a higher initial microbial load than the turkey. These factors may have been responsible for the differences we noted between chicken and turkey frankfurter products.

Sorbic acid was reported by Perry et al. (1964) and Cunningham (1979) to prolong shelf life of broilers. Our results on gas production by the indigenous microflora also indicate that sorbic acid is effective in controlling the contaminating bacteria. Commercial type emulsions and frankfurters containing 135 ppm nitrite showed less gas formation than those containing 0.2% sorbic acid and were about the same as 0.4% sorbic acid or acidified 0.2% sorbic acid products.

The growth of and toxin production by *C. botulinum* in the completed frankfurters were also prevented for longer periods of time than in the emulsions, indicating that changes occurred during smoking that were deleterious to *C. botulinum*. The indigenous microflora also led to longer mean swell times in the completed frankfurters than in the emulsions. These observations indicate that the use of emulsions or ground frankfurters with additions of spores after their preparation may not produce results similar to naturally contaminated products.

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Reference to brand or firm name does not constitute endorsement by the U.S. Dept. of Agriculture over others of a similar nature not mentioned.

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