

# UTILITY OF BLANCHING IN FOOD CANNING EFFECT OF COLD SHOCK UPON BACTERIAL DEATH RATES

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The so-called process of blanching is used both by commercial packers and by the housewife in preparing many vegetables and fruits for preservation by canning. The physical advantages of dipping such food first into boiling water, then into cold, are probably sufficient to justify its use. However, there is a distinct impression prevalent among canners that the blanching is to some degree an essential part of the process of sterilization, and that products so treated are more readily processed. This report presents the results of a series of studies on the effect of cold shock upon bacterial death rates when organisms are subjected to subsequent high temperatures. It has been thought that the cold shock following a preliminary heating might so injure the vitality of the bacteria as to make them more susceptible to subsequent heating.

In a preliminary note presented in December 1917, at the meeting of the Society of American Bacteriologists,<sup>1</sup> the conclusion was announced that there is no evidence that heat and cold shock increase the susceptibility of bacterial spores to heat, for death rates of such bacteria are not increased during a second heating beyond the death rates of "unshocked" bacteria subjected to the same temperature.

In a recent paper, Bushnell<sup>2</sup> comes to a similar conclusion as a result of studies on the canned products themselves.

This paper presents data in support of the conclusion announced in our preliminary note, with certain inferences which may be drawn as to the utility of the blanching process in cold pack canning.

It is obvious that the times and temperatures used in both commercial and home canning processes are such that organisms other than those in the spore condition will be very quickly destroyed. It is necessary, then, to study the effect of cold shock upon the vitality or viability of bacterial spores.

The organism used in this study was *Bacillus pseudotetanicus* (Kruse) Migula, a member of the group of spore-producing soil aerobes possessing considerable resistance to high temperatures. The parent culture was one secured from Dr. Ford, of Johns Hopkins. The bacteria were grown on 0.5 per cent dextrose agar slants, incubated at 30° C. for four days to insure adequate sporulation. The growth from a single culture was suspended in 10 cc. physiological salt solution. This suspension was centrifugated to remove clumps and passed through a sterile filter to secure a uniform suspension. In all cases the effect of temperature was studied by adding 1 cc. of this suspension to 9 cc. of 1 per cent peptone solution already heated to the desired temperature. A de Khotinsky portable water bath was used for maintaining a constant temperature, with corn oil substituted for water, as ex-

perience showed a much more constant temperature could be maintained at 80° C. and above by this means. The peptone solution was held at the temperature of the bath for the desired length of time, counts of the numbers of viable bacteria present being made at short intervals by plating. At higher temperatures the time intervals used were necessarily shorter than at lower temperatures. After the heating had been continued for the desired length of time, 1 cc. was transferred to a second tube of peptone containing 9 cc. of solution and at a temperature of about 1° C. maintained by the use of an ice bath. The length of exposure to the cold was arbitrarily fixed in each case at 5 min. A sample was then taken for a plate count, and the tube placed in the thermostat where it was heated together with the tube containing the "unshocked" bacteria.

Counting was carried out in general in conformity with standard methods. Salt solution was used for dilutions. The plating medium used was a 1 per cent dextrose, 2 per cent agar. This gave a relatively stiff medium and prevented the development of spreading colonies, a serious difficulty with softer media. The plates were incubated at 30° C. for 48 hrs., then counted.

It has been shown by several investigations that the deaths of microorganisms when subjected to any fixed unfavorable conditions will occur in conformity with the well-known equation of monomolecular reactions. This may be expressed:

$$k = \frac{1}{t} \log \frac{B}{b}$$

in which  $k$  = velocity coefficient of the rate of death of bacteria, a constant

$t$  = interval of time between observations

$B$  = number of bacteria at beginning of any time interval

$b$  = number of bacteria at end of time  $t$

Preliminary tests with the spores of *Bacillus pseudotetanicus* showed satisfactory agreement with the law; under a given set of conditions the value of  $k$  was found to be nearly constant, that is, the number of bacteria dying off in any unit of time is nearly proportional to the number present at the beginning of that time interval. It is evident that the effect of the cold shock upon bacterial spores may be determined by a comparison of the values of  $k$  found before and after "shocking" the bacteria, i. e., if the value of  $k$  increases, the spores have lost their resistance to some degree and die off more quickly than do the "unshocked" bacteria.

It is apparent that considerable experimental error is inevitable. The results, however, are on the whole satisfactory.

Several methods may be used for calculating the value of  $k$  in any experiment. It is evident that the initial inoculum probably may contain some viable vegetative cells which will have a very different death rate from spores. The value of  $k$  may be approximated by (1) substituting for  $B$  the number of bacteria at beginning, for  $b$  the number of bacteria after

<sup>1</sup> *Abstracts of Bact.*, 2 (1918), 5.

<sup>2</sup> "The Influence of Cold Shock in the Sterilization of Canned Foods," *THIS JOURNAL*, 10 (1918), 432.

the varying time intervals, and averaging, or (2) substituting for  $B$  the number of bacteria at beginning of each time interval, and for  $b$  the number at the end of each time interval, and averaging, or (3) substituting for  $B$  the number of bacteria at the end of the first time interval, and for  $b$  the number of bacteria after each of the following time intervals, and averaging. The values of  $k$  were determined by each method as illustrated by the following example:

TABLE I—ILLUSTRATING METHODS OF DETERMINING VELOCITY COEFFICIENT ON DEATH RATE AT 80° C.

Time after Inoculation Min.	Viable Bacteria per cc.	$k$ Calculated by Method 1	$k$ Calculated by Method 2	$k$ Calculated by Method 3
0	890,000	0.0021	0.0021	
15	827,000	0.0024	0.0027	0.0027
30	752,000	0.0025	0.0028	0.0028
45	681,000	0.0029	0.0039	0.0031
60	594,000	0.0028	0.0026	0.0031
75	537,000	0.0027	0.0021	0.0028
90	504,000	0.0032	0.0062	0.0029
105	406,000			
	Ave., 0.0026	Ave., 0.0032	Ave., 0.0029	

It is apparent that in this instance there is little to choose in the method of determining  $k$ . It is thought, however, that either the third, or an average of the averages, should represent the facts fairly well. In general, the latter index has been used.

#### EXPERIMENTAL RESULTS

Three sets of experiments were run at 80°, one at 85°, two at 90°, and one at 100° C. The data and determined values for  $k$  are given in the following tables:

TABLE II—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 80° C. FIRST TRIAL

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 15 min.	Shocked after Heating 30 min.
0	890,000		
15	827,000	81,000	70,300
30	752,000	72,000	67,100
45	681,000	60,350	64,000
60	594,000	59,650	
75	537,000	57,700	55,200
90	504,000	54,200	48,100
105	406,000	53,200	43,300
Value of $k$	0.0029	0.0025	0.0021

It will be noted that the values for the velocity coefficients of the death rates of the shocked bacteria are not higher than those of the unshocked. The differences are probably not significant. The general tendency in this and other experiments is for the value for the shocked bacteria to be slightly lower. This may possibly be due to unavoidable experimental error in that the chilled tube does not instantly assume the desired temperature when replaced in the water bath.

TABLE III—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 80° C. FIRST TEST

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 15 min.	Shocked after Heating 30 min.
0	130,000	20,000	6,800
15	110,000		
30	60,000	6,900	4,650
60	30,000	2,800	3,000
90	13,500	1,150	
Value of $k$	0.0115	0.0136	0.0059
SECOND TEST			
0	189,000	10,000	6,200
15	125,000	7,500	
30	82,000	4,700	4,700
60	34,000	2,300	2,800
90	32,000	1,000	1,880
120	15,200	800	960
135			360
150	6,300	360	
165		320	
Value of $k$	0.0106	0.0104	0.0065

The results in Table III are not comparable strictly and directly with those of Table II as these tests were performed with different lots of material.

Here again the differences in rates of death are probably not significant. In each of the following experiments it should be noted that the studies were made with different lots of material. The values of  $k$  determined in the various tables cannot be used therefore for a determination of the temperature coefficient of the reaction. Conditions were uniform in each experiment, but suspensions of bacteria prepared at different times did not give comparable results.

TABLE IV—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 85° C.

Unshocked Bacteria		Shocked after Heating 10 min.	
Time after Inoculation Min.	Viable Bacteria	Time after Inoculation Min.	Viable Bacteria
0	2,180,000	0	183,000
10	1,850,000	5	173,000
20	1,089,000	25	116,000
40	621,000	50	88,000
65	45,600	60	27,000
Value of $k$	0.0127	..	0.0107

TABLE V—DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 90° C.

Unshocked Bacteria		Shocked after Heating 10 min.	
Time after Inoculation Min.	Viable Bacteria	Time after Inoculation Min.	Viable Bacteria
0	481,000	0	22,600
10	296,000	15	10,700
20	67,000	30	5,000
35	26,000	45	570
50	2,900	65	340
65	2,200	75	135
Value of $k$	0.0384	..	0.0285

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after Heating 5 min.	Shocked after Heating 10 min.
0	990,000	89,000	
5	810,000	61,500	35,300
10	790,000	57,000	34,500
15	357,500	51,000	29,500
20	164,500	37,100	
25	137,500	29,600	24,500
30	101,000	25,600	23,400
35	94,000	22,350	12,500
Value of $k$	0.0292	0.0180	0.0108

TABLE VI—SINGLE DETERMINATION OF VELOCITY COEFFICIENT OF DEATH RATE AT 98° C.

Time after Inoculation Min.	Viable Bacteria per cc.		
	Unshocked Bacteria	Shocked after 2 min.	Shocked after 4 min.
0	125,000	6,600	5,600
2	51,000	5,900	5,200
4	30,000	5,400	4,800
6		4,700	4,600
8	26,000	3,000	3,100
10	14,700	2,200	2,500
12	5,500	920	
Values of $k$	0.1106	0.0504	0.0257

It is evident that the experimental error for results such as given in Table VI should be rather large because of the difficulties in rapid manipulation, slowness with which tubes acquire a new temperature, and inaccuracies in correct estimation of time.

TABLE VII—SUMMARY OF THE VALUES OF  $k$  OBTAINED FOR DIFFERENT TEMPERATURES

Temperature	Value of $k$ for Unshocked Bacteria	Value of $k$ for Shocked Bacteria	Value of $k$ for Shocked Bacteria
90°	0.0029	0.0025	0.0021
80°	0.0115	0.0136	0.0059
80°	0.0106	0.0104	0.0065
85°	0.0127	0.0107	..
90°	0.0384	0.0285	
90°	0.0290	0.0180	0.0108
100°	0.1106	0.0504	0.0257

A summary of the values of  $k$  is given in Table VII. It will be noted that in one case only does the velocity coefficient of the death rate of shocked bacteria rise higher than the unshocked. An examination of this

table apparently justifies the statement that the rate of death of bacteria at high temperatures is not increased by preliminary heating and "shocking" by cold. The bacteriological utility of the blanching in the cold pack process of canning probably should not be ascribed to shock.

Is there, then, any bacteriological justification for the process of blanching in food canning? A can of food is sterile and will certainly keep in consequence whenever the number of living bacteria present, or the number of those which can multiply in the canned food, has been reduced to fewer than one to the can. The fact that sporulating bacteria die off at high temperatures in substantial conformity to the law governing monomolecular reactions emphasizes the point that the larger the number of bacteria initially present in the can, the longer under the same conditions will it take to sterilize. Blanching may be of some value because the initial application of hot water followed by cold not only kills many bacteria but removes them from heavily contaminated products in very large numbers. It is probable that there is some bacteriological justification for the blanching process because of this initial cleansing.

It may be noted that Bushnell's experiments on blanching were not in all cases, strictly speaking, blanching in the sense used in the cold pack process. This author demonstrated that if a food is heated, chilled, and heated, the total time of heating required to sterilize is as great as though there had been no chilling. This does not prove, however, that if the material had been immersed in boiling water, then in cold water, that the cleansing action may not have increased the ease of sterilization. This could be determined by quantitative determinations of the spores removed by this process. It is not improbable in many cases that the time of sterilization required with and without blanching would be practically identical, indicating that the number of bacteria (spores) removed was not very great. This is indicated by other results of Bushnell's where true blanching was practiced. A comparative study should also be made of the composition of the liquid of canned foods, vegetables in particular, which have been blanched with that from unblanched. Very slight differences in the acidity (hydrogen ion concentration) of the liquid under the two conditions might influence markedly the time needed for sterilization.

#### CONCLUSIONS

1—Comparisons of the velocity coefficients of the death rates of bacterial spores may be made to determine the effect of various conditions, such as temperature.

2—Bacterial spores are apparently not made more sensitive to heat by preliminary heating followed by chilling.

3—Blanching as a preliminary to the cold pack process of canning does not have bacteriological justification on the basis of increased susceptibility of the bacteria to sterilization because of "cold shock."

4—There is probably some bacteriological justification for blanching because of the marked cleansing

action of this process, resulting in the introduction of smaller numbers of spores initially into the canned product. It is probable that the time required for sterilization varies with the initial contamination; it is desirable therefore to reduce this as much as possible.

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#### THE NATURE OF THE RECOMBINED POTASH IN CEMENT MILL DUST

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In a previous publication<sup>1</sup> an estimate was made of the quantity of potash annually recoverable as a by-product in the flue dust of the cement mills of the United States. Attention was also called to the fact that in cement dusts which have been recovered a portion of the potash in the dust has been found to be insoluble in acids; a second portion insoluble in water, as determined by the official methods of the Association of Official Agricultural Chemists, but readily soluble in acids, while the remainder of the potash is soluble in water. In the oil-fired plant of the Riverside Portland Cement Company, where cement dust was first collected for its potash content, the greater part of the potash in the dust is readily water-soluble. This dust also contains some acid-soluble and acid-insoluble potash, but the proportions of these present are too small to be of practical significance. However, when dust was later collected at plants where coal is used for fuel it was found that in such plants the acid-soluble potash may constitute the greater part of the total potash in the dust and thereby greatly depreciate the value of the dust for sale as a fertilizer. This observation was first made at the plant of the Security Cement and Lime Company by Mr. R. C. Haff, Chief Chemist, and Mr. R. D. Cheesman, at that time Assistant Chemist of the Company. In explanation of the result the view was advanced by R. J. Nestell and E. Andersen,<sup>2</sup> of the Western Precipitation Company, that the potash occurring in the acid-soluble form was due to a recombination within the kiln of the volatilized potash with the siliceous ash particles of the coal used for fuel.

In a recent article by N. S. Potter, Jr., and R. D. Cheesman<sup>3</sup> the view is advanced, on the other hand, that there is no recombination of the volatilized potash with the siliceous ash particles, but that the water-insoluble potash in the dust is due to the potash in the ash of the coal used for fuel and in the raw mix carried over mechanically in the dust. After quoting passages from articles by Nestell and Anderson<sup>4</sup> and by the authors,<sup>5</sup> the statement is made that the potash content of the coal ash had hitherto been quite neglected in considering the sources of the potash occurring in cement dust.

<sup>1</sup> W. H. Ross, A. R. Merz, and C. R. Wagner, U. S. Dept. Agr., *Bulletin* 572.

<sup>2</sup> *This Journal*, 9 (1917) 646.

<sup>3</sup> *Ibid.*, 10 (1918), 109.

<sup>4</sup> *Ibid.*, 9 (1917), 646.

<sup>5</sup> *Ibid.*, 9 (1917), 467, 1035.