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SURVIVAL OF PATHOGENIC BACTERIA IN FOODS PREPARED WITH WHOLE EGG SOLIDS

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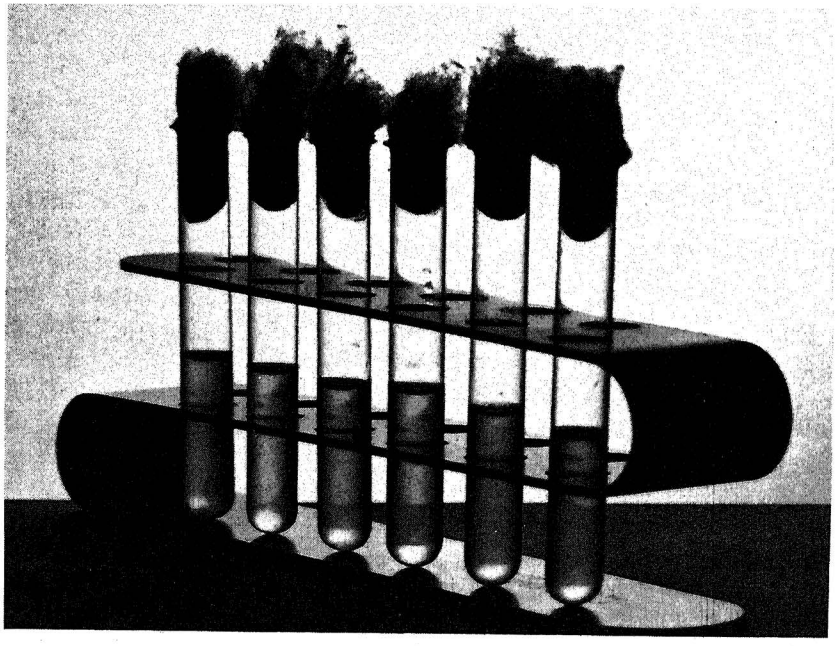

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TABLE OF CONTENTS

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SURVIVAL OF PATHOGENIC BACTERIA IN FOODS PREPARED WITH WHOLE EGG SOLIDS

TREVA C. KINTNER and MARGARET MANGEL

INTRODUCTION AND PURPOSE OF INVESTIGATION

Before the war, China was the largest producer of egg solids and, because of cheap labor and production, had supplied inexpensively most of the egg solids for this country. With supplies curtailed during the war and with increased demand for this easily shipped commodity, American plants greatly increased production of egg solids. Around 180 thousand pounds of whole egg solids were produced in 1939 in the United States, and five years later production reached a peak at over 300 million pounds. Priebe (1953). Because the egg drying industry expanded so rapidly, many problems resulted. Egg solids before 1940 were used in foods for their functional qualities, while flavor and nutritive value were not of major importance.

During the war years of 1942, 1943, and 1944, the Department of Agriculture purchased over 200 million pounds of whole egg solids each year to be used for food by the armed services and our allies. While the initial quality of much of the egg solids produced during these early years of the war was good, the product often deteriorated between the time of production and use. Solowey (1951). Prejudices were built up against egg solids when they were used after long periods of storage at high temperatures. As a result of an extensive cooperative research program, Conrad and others (1948), the following precautions and procedures have been shown to improve the stability of flavor, nutritive value, functional properties, and to tend to minimize bacterial contamination. Solowey (1951), Schneider (1951), Priebe (1953), Goresline and others (1951), Lineweaver and Feeney (1951), and Proctor and others (1953):

1. Use of only good quality eggs for drying.
2. Pasteurization of the eggs before drying.
3. Improvement of sanitation during production.

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4. Increase of acidity of dried eggs to a pH of 5.5 before drying.
5. Production of low moisture content in the final product.
6. Use of tin cans and inert gases in packaging.
7. Control of sugar-protein reaction by desugaring.
8. Use of better storage practices.
9. Use of egg solids soon after reconstitution.
10. Use of cathode ray irradiation.

Many of the improvements suggested from experimental studies on egg solids have been carried out, and the egg solids on the market today are much superior to the early product. The description given by Fidler (1951) of the improved egg solids produced in 1951 is quoted here:

> Under the modern process, the liquid egg is treated with dilute hydrochloric acid to a pH of 5.5 before entering the drying chamber. In order to restore the normal pH of the acidified powder during the reconstitution, sodium bicarbonate is added to the dry powder. When water is added, the bicarbonate reacts to neutralize the acid. The powder contains not more than two per cent moisture and is packed in tins with nitrogen and carbon dioxide mixtures.

Although additional research is necessary, the manufacturers need to make greater use of the improvements now recommended. While much of the research has been done on flavor and baking characteristics, a number of studies have been reported on the nutritive value of egg solids. This product is considered an excellent source of proteins, fats and other nutrients. Pantothenic acid and niacin are found to be stable, and riboflavin and vitamin A are retained in egg solids if packaged properly. If the moisture is kept quite low the thiamine is stable. Whitford and others (1951).

Most of the bacteriological reports in the literature are on egg solids themselves and not on foods prepared with egg solids. Johns and Berard (1945) report that the occurrence of practically pure cultures of bacteria in dried egg suggests that a single egg is responsible for the contamination. Solowey (1951) states that since the shell egg is in an individual package, contamination is not so widespread in fresh eggs. Goresline (1943) suggests one musty egg may contain millions of bacteria and have odor and flavor strong enough to affect large batches of good eggs. These contaminated eggs must be eliminated or the egg solids will be of low edible quality. Solowey and others (1947) reported that the presence of enteric food poisoning Salmonella in meat or animal products is a potential hazard. Hinshaw and McNeil (1951) stated that children are particularly susceptible to the hazard of Salmonella infection due to uncooked or partially cooked contaminated eggs. While cases of food poisoning conclusively traced to contaminated

egg powders are rare, recent research on the pathogenicity of two strains of Salmonella isolated from egg solids, reported by McCullough and Eisele (1951), proved these strains to be very toxic to humans.

For the future, it is hoped that completely safe, palatable, inexpensive egg solids of high nutritive value will be readily available for use by the housewife. Egg solids today are available only in 5 pound tins. One pound of whole egg solids is equivalent to 36 to 40 eggs. According to Edward W. Priebe, Jr., merchandising director of the Institute of American Poultry Industries, (1953) it will be 3 to 5 years before one pound packages will be available on the market for the housewife.

After the government stopped buying eggs the production of whole egg solids dropped from 85 million to 10 million pounds. Although the production of whole egg solids has decreased, there is now a trend toward increased production because of the many uses of egg solids in complete prepared mixes. In 1952 it is estimated that about 17 million pounds of white, yolk or whole egg solids were produced. The greatest demand at present appears to be for egg white solids for use in angel food and white cake mixes.

The advantages of the use of egg solids are many and include: A minimum cost, because the eggs are dried when egg production is at its peak; savings on transportation costs are effected; no waste, spoilage or breakage results. Also, baking and cooking performance is standardized and made uniform, and the original nutritive value retained. Trends in research point to egg solids of exacting laboratory safeness. Priebe (1953) and Stewart (1948).

With the present product it is important to define conditions under which egg solids may be used. The U.S.D.A. BHNHE Bulletin No. 136 (1950) suggests: " . . . do not make milk drinks, mayonnaise, omelets, scrambled eggs, cream puddings or fillings, soft custards, ice creams or cooked salad dressing with dried eggs." This limitation on the use of egg solids is based, according to Goddard (1950), on studies such as those reported in a preceding paragraph on the bacteria present in egg solids.

In one of the few bacteriological studies on the use of egg solids in preparing foods, Solowey and Calesnick (1948) found artifically and naturally contaminated scrambled eggs only occasionally to yield viable Salmonella. Wethington and Fabian (1950) reported a study in which commercial and laboratory prepared mayonnaise and salad dressing, prepared from fresh or frozen eggs, was experimentally inoculated with Staphylococci and Salmonellae. These authors considered salad dressings, due to their acid content, not a probable source of food poisoning.

Edwards and others (1948) reported that *Salmonella choleraesuis* was obtained both from cultures of mayonnaise and from a person who was ill after eating mayonnaise. However, the problem is somewhat different in mayonnaise than in salad dressing since mayonnaise is not heated and has a higher pH.

The series of experiments at the University of Missouri was undertaken to define conditions under which the present egg solids product might safely be used in cooked salad dressings, puddings and custards.

The research on cooked salad dressing was undertaken because both heat and acid were considered to be effective methods of destroying pathogenic micro-organisms that might be found in foods. The acidity of the salad dressing was varied in order to study the influence of acid on bacteria inoculated into salad dressing after cooking. In addition, seven food poisoning bacteria were inoculated into egg solids before cooking salad dressings, to check the influence of heat in the presence of acid on the survival of the bacteria.

Puddings and custards both have a pH near neutral and are known to be good media for bacterial growth, if contaminated either artifically or naturally after cooking. Hence, for these products, the egg solids were contaminated before cooking only. Special emphasis was placed on the effect of temperature on survival of bacteria in puddings and custards. The sugar content of the vanilla puddings was increased to the sweetness typical of pie filling and the influence of this increased sugar concentration on survival of the bacteria was determined. The survival of pathogenic micro-organisms in chocolate and butterscotch puddings, which are slightly more acid than vanilla, was studied.

Both stirred and baked custards were prepared from artifically contaminated egg. The use of egg solids has been recommended in baked but not in stirred custards. The temperature necessary to coagulate the contaminated egg used in the custards, both stirred and baked, and its influence on the survival of the food poisoning bacteria, were points considered in this part of the study.

Samples of all the puddings and custards prepared with the artifically contaminated egg were held at room temperature and other samples were refrigerated.

EXPERIMENTAL PROCEDURE

Bacteriological Methods

The bacteria used in this study were obtained from the Bacteriology Departments of the University of Missouri Medical and Veterinary Medical Schools, and from Dr. Philip Edwards of the Public Health Service, Chamblee, Georgia.

Listed below are the organisms used in the bacteriological studies of the food products prepared with whole egg solids:

ORGANISM	PRODUCT		
	Salad dressings	Puddings	Custards
Micrococcus pyogenes var. *aureus (Staphylococcus aureus)*	x	x	x
Salmonella typhimurium (aertrycke)	x	x	x
Salmonella enteritidis	x	x	x
Salmonella pullorum no. 19	x	x	x
Salmonella pullorum no. 20	x		
Salmonella gallinarum	x	x	x
Salmonella choleraesuis	x	x	x
Salmonella orienburg		x	x
Salmonella anatum		x	x

Representative samples of each of the seven bacteria used in the cooked salad dressings and the eight used in puddings and custards were grown at 37° C. for 24 hours in nutrient broth. For inoculation of the egg powder, broth-bacteria culture was used in place of 15 milliliters of water in reconstituting the equivalent of one egg. For the contamination of the salad dressing after cooking, one milliliter of the broth-bacteria culture was added and thoroughly mixed.

As soon as the salad dressings, puddings and custards were made, samples were placed in sterilized flasks and transfers were made immediately and after 1, 2, 3, 4, and 24 hours. Bacto-Tryptose agar (Difco) plates were used to check for the growth of Staphylococci and S.S. (Shigella-Salmonella) agar (Difco) plates were used to check for possible Salmonella growth. The plates were incubated at 37° C. for 24 hours. If bacterial colonies were present, they were identified by growth and morphologic characteristics. If growth appeared on the S.S. agar plates, representative colonies were transferred to Kliger's Iron agar (Difco) slants to prove the presence of Salmonella. These slants were incubated at 37° C. for 24 hours and compared with original checks made on Kliger's Iron agar slants inoculated with a drop of nutrient broth-bacteria culture.

The eggs were reconstituted using 12 grams with 30 milliliters of water as equivalent to one fresh egg. If part of the sugar was mixed with the egg solids, and if warm water was used in the reconstitution, a consistently smoother product resulted. The reconstituted egg solids were always used within fifteen minutes after reconstitution. The

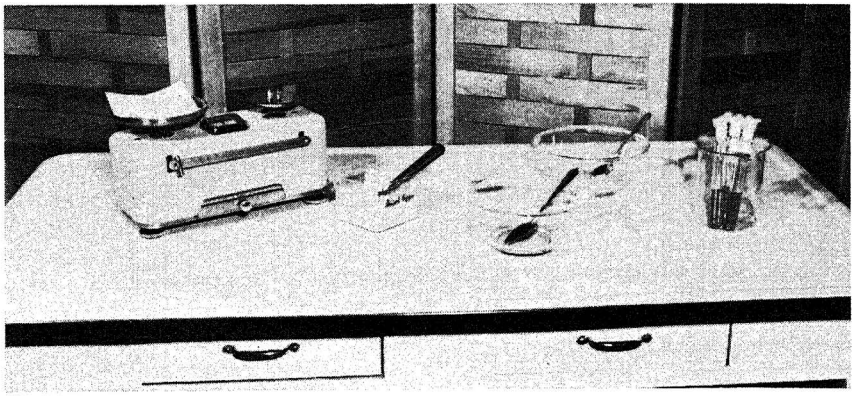

Fig. 1 — Contaminating dried eggs during reconstruction.

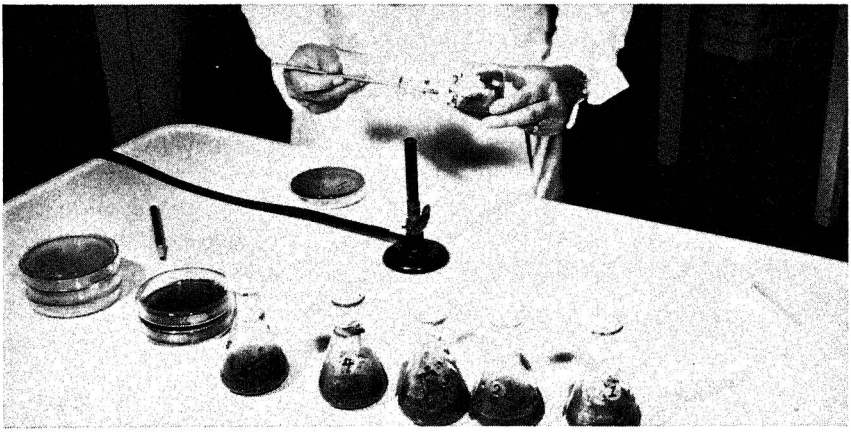

Fig. 2 — Testing contaminated products for bacterial growth.

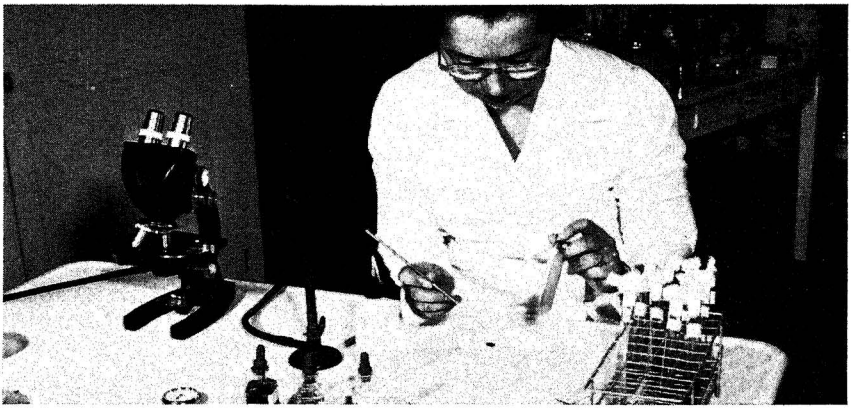

Fig. 3 — Identifying recovered bacteria.

egg solids were obtained from the F. W. Stamper Company, Moberly, Missouri.

The temperature was taken internally by accurate centigrade mercury thermometers. The custards were baked in an oven that was checked by an oven tester (Frigidaire) which works on the thermocouple principle. The pH of the products was determined electrometrically on the Beckman pH meter at 25° C.

Salad Dressings

1. Formula

In order to obtain a cooked salad dressing which was desirable in flavor and texture, five recipes were tested. That recipe considered most desirable for use in such dishes as potato, bean, macaroni and meat salads was adapted as the basic formula. Amounts and methods of addition of the ingredients were varied to check their influence on the final product. The vinegar and sugar were increased to find palatable salad dressings of varying pH's. Variation in the pH of the final product was shown to be related to the pH of the vinegar used. Considerable variation in pH was found in the same type of vinegar and even in that bottled under the same brand name. The cider vinegars used in these experiments had a mean pH of 3.34 and were considered mild in flavor. The method of making and the formula were standardized. The basic formula and variations are listed in Table 1. The procedure used in the preparation of the salad dressings was as follows:

The fat was melted in the top of a double boiler over direct heat. The flour was mixed with the melted fat. The water and milk were added and the four ingredients were cooked over direct heat for one minute to an internal temperature of 98° to 100° C. The reconstituted egg solids and sugar mixture was added to the above white sauce and cooked in the double boiler to an internal temperature of 84° to 86° C. or for one-half minute. The vinegar and spices were added after the salad dressing was removed from the heat.

TABLE 1 -- BASIC SALAD DRESSING FORMULA AND VARIATIONS

	Basic Formula		Variation I		Variation II		Variation III		Variation IV	
INGREDIENTS	Weight in grams	Measure in T.	Weight in grams	Measure in T.	Weight in grams	Measure in T.	Weight in grams	Measure in T.	Weight in grams	Measure in T.
Fat	26	2	26	2	26	2	26	2	26	2
Flour	18	2 1/3	18	2 1/3	18	2 1/3	18	2 1/3	18	2 1/3
Milk	122	8	122	8	122	8	122	8	122	8
Water	150	10	150	10	150	10	150	10	150	10
Dried Egg	12	2	12	2	12	2	12	2	12	2
Sugar	28	2 1/3	48	4	72	6	96	8	120	10
Salt	3.8	3/4 t.	3.8	3/4 t.	3.8	3/4 t.	3.8	3/4 t.	3.8	3/4 t.
Dry Mustard	2	3/4 t.	2	3/4 t.	2	3/4 t.	2	3/4 t.	2	3/4 t.
Paprika	.5	1/16 t.	.5	1/16 t.	.5	1/16 t.	.5	1/16 t.	.5	1/16 t.
Vinegar	42	3	70	5	98	7	126	9	252	18
pH as tested	4.56		4.21		4.08		3.95		3.40	

2. Study of the Effect of Acidity on the Bacteria Inoculated Into Cooked Salad Dressing

The basic salad dressing formula and four variations (Table 1) were used in this part of the study. Thirty grams of the basic salad dressing was put into each of seven sterilized flasks. One milliliter of a 24 hour nutrient broth-bacteria culture of one of the seven bacteria was added to each flask and thoroughly mixed by shaking for one-half minute. The four variations were made and contaminated in a similar manner. The contaminated salad dressings were held at room temperature and transfers were made immediately and after 1, 2, 3, 4, and 24 hours onto plates, which were checked for bacterial growth.

3. Study of the Effect of Temperature on Bacteria Inoculated Into Reconstituted Egg Used in Preparing Cooked Salad Dressing

Only the basic salad dressing formula was used in this phase of the study. The reconstituted egg mixture was contaminated by using inoculated broth-bacteria culture in place of part of the water. Separate salad dressings were made for each of the seven bacteriological studies.

Special emphasis was placed on keeping the cooking temperature constant for each of these salad dressings. The white sauce was cooked for one minute at 98° C. The contaminated egg mixture was added and cooked in the top of a double boiler for one-half minute or to a temperature of 84° to 86° C. After the salad dressings were made, the same conditions, media, and procedures were used to check bacterial growth as stated in the bacteriological methods.

Puddings

In order to obtain vanilla, butterscotch and chocolate puddings which were typical in flavor and texture, various recipes were tested until a good basic formula for each type was obtained. In the vanilla puddings, the sugar was increased to prepare products of 18 to 25% sugar concentration. The formulae used are reported in Table 2.

The procedure for making the puddings was standardized, using a definite cooking time for both the starch and the reconstituted egg. The starch mixture was cooked in the top of the double boiler for 12 minutes or to an internal temperature of 92° to 98° C. The contaminated egg was added and cooked for one-half minute. A temperature range of 78° to 86° C. was obtained for the cooked egg mixture. The temperature obtained for each type of pudding was fairly constant and varied according to the variation in the temperature of the starch mixture. The lower temperatures of 78° to 79° C were evident in the

TABLE 2 -- VANILLA, BUTTERSCOTCH AND CHOCOLATE PUDDING FORMULAE

	Vanilla 12% sugar		Vanilla 18% sugar		Vanilla 25% sugar		Chocolate		Butterscotch	
INGREDIENTS	Weight in grams	Measure	Weight in grams	Measure	Weight in grams	Measure	Weight in grams	Measure	Weight in grams	Measure
Dried egg	12	2 T.	12	2 T.	12	2 T.	12	2 T.	12	2 T.
Water	30	2 T.	30	2 T.	30	2 T.	30	2 T.	30	2 T.
Milk	488	2 C.	488	2 C.	488	2 C.	488	2 C.	610	2 1/2 C.
Sugar	66	1/3 C.	102	1/2 C.	158	3/4 C.	102	1/2 C.		
Salt	1	1/4 t.	1	1/4 t.	1	1/4 t.	1	1/4 t.	1	1/4 t.
Vanilla	4	1 t.	4	1 t.	4	1 t.	4	1 t.	4	1 t.
Cornstarch	16	2 T.	16	2 T.	16	2 T.	16	2 T.	16	2 T.
Brown sugar									132	2/3 C.
Chocolate							28	1 sq.		
Butter									13	1 T.

25% sugar vanilla puddings where large amounts of sugar were mixed with the egg in reconstitution. The pudding samples were placed in sterilized flasks and bacterial growth determined from transfers made immediately, and after 1, 2, 3, 4, and 24 hours, from those products held at room temperature, and after 24 hours from those held at refrigerator temperature.

Custards

The basic custard recipe was used in both the stirred and baked custards. This formula is reported in Table 3. For the stirred custard, the cold ingredients were combined and cooked over boiling water for 5 to 6 minutes or until an internal temperature of 91° to 93° C. was reached. In custards made with dried eggs, a higher temperature produced a curdled product and a lower temperature resulted in insufficient thickening of the custard.

For the baked custard, the cold ingredients were combined and placed in custard cups which were surrounded with water, and baked in a controlled oven at 325° F. for approximately 45 minutes. At this stage the internal temperature was about 91° C.

The custards were prepared from eggs that were contaminated as previously described. The custard samples were placed in sterilized jars, and transfers were made from custards held at both room and refrigerator temperatures and plates were examined to check for bacterial growth as described in the bacteriological methods.

Preliminary Study of Bacteria Present in Whole Egg Solids

Five culture checks were made to test for possible bacteria in the egg solids. The eggs were reconstituted under sterile conditions. Twelve grams of whole egg solids was mixed with 30 milliliters of water and carefully stirred for one minute. The reconstituted egg was transferred by an inoculating loop, immediately and after 1, 2, 3, 4, and 24 hours,

TABLE 3 -- BASIC CUSTARD FORMULA

INGREDIENTS	Stirred Custard		Baked Custard	
	Weight in grams	Measure	Weight in grams	Measure
Dried egg	24	4 T.	24	4 T.
Water	60	4 T.	60	4 T.
Milk	488	2 C.	488	2 C.
Sugar	50	4 T.	50	4 T.
Salt	.5	1/8 t.	.5	1/8 t.
Vanilla	4	1 t.	4	1 t.

to tryptose and S.S. agar plates to check for possible pathogenic organisms. These plates were incubated for 24 hours at 37° C. and the growth on the plates was identified by morphologic and growth characteristics. No pathogenic bacteria were found in these few culture checks.

RESULTS AND DISCUSSION

Salad Dressings

1. Influence of pH

Table 4 shows a complete record of the survival of bacteria inoculated into the salad dressings of the five different pH's. Only two of the bacteria, *Salmonella choleraesuis* and *Salmonella pullorum* no. 20, were inhibited at the pH of the basic formula. The more resistant of the Salmonella to the acid conditions of the salad dressing were *Salmonella enteritidis* and *Salmonella typhimurium*. The growth of these micro-organisms was inhibited at a pH of 3.40. The most persistent of all bacteria studied was the *Staphylococcus aureus* and it remained viable when incubated for four hours in a salad dressing with a pH of 3.40. Wethington and Fabian (1950) also reported that the strains of Staphylococci they tested were more resistant to acid conditions than the Salmonellae. The pH of the basic salad dressing, which was considered best in texture and flavor, was not acid enough to destroy all bacteria inoculated into it. Variations I, II and III with progressively lower pH's showed increasing tendency to prevent bacterial growth. Variation IV, though not desirable in texture and flavor, inhibited the growth of all bacteria tested.

2. Influence of Temperature

The cooking of the egg mixture to a temperature of 84° to 86° C. at the pH obtained in the basic salad dressing formula, effectively inhibited the growth of all the bacteria inoculated into the egg solids.

Puddings

Table 5 records the viability of the bacteria in the puddings prepared with experimentally inoculated egg solids. Survival of three

TABLE 4 -- VIABILITY OF BACTERIA IN COOKED SALAD DRESSING OF VARYING pH

Test Organism	Hours held	Plate growth at indicated pH: 4.56 Basic formula	4.21 Variation I	4.08 Variation II	3.95 Variation III	3.40 Variation IV
Staphylococcus aureus	0	+	+	+	+	+
	1	+	+	+	+	+
	2	+	+	+	+	+
	3	+	+	+	+	+
	4	+	+	+	+	+
	24	+	+	+	+	-
Salmonella typhimurium	0	+	+	+	+	+
	1	+	+	+	+	+
	2	+	+	+	+	-
	3	+	+	+	+	-
	4	+	+	+	+	-
	24	+	+	+	+	-
Salmonella enteritidis	0	+	+	+	+	+
	1	+	+	-	+	-
	2	+	+	-	-	-
	3	+	+	-	-	-
	4	+	+	-	-	-
	24	+	+	-	-	-
Salmonella pullorum (19)	0	+	+	+	-	+
	1	+	+	+	-	-
	2	+	+	-	-	-
	3	+	+	-	-	-
	4	+	+	-	-	-
	24	+	-	-	-	-
Salmonella gallinarum	0	+	+	-	-	-
	1	+	+	-	-	-
	2	+	+	-	-	-
	3	+	+	-	-	-
	4	+	+	-	-	-
	24	+	-	-	-	-
Salmonella pullorum (20)	0	+	-	-	-	-
	1	+	-	-	-	-
	2	-	-	-	-	-
	3	-	-	-	-	-
	4	-	-	-	-	-
	24	-	-	-	-	-
Salmonella choleraesuis	0	+	-	-	-	-
	1	-	-	-	-	-
	2	-	-	-	-	-
	3	-	-	-	-	-
	4	-	-	-	-	-
	24	-	-	-	-	-
Control	0	-	-	-	-	-
	1	-	-	-	-	-
	2	-	-	-	-	-
	3	-	-	-	-	-
	4	-	-	-	-	-
	24	-	-	-	-	-

TABLE 5 -- VIABILITY OF BACTERIA INOCULATED INTO EGG SOLIDS USED IN PREPARING PUDDINGS AND CUSTARDS

Test Organisms	Hours held at room temperature	Plate growth of						
		Pudding					Custard	
		Vanilla						
		12% Sugar	18% Sugar	25% Sugar	Chocolate	Butter-scotch	Stirred	Baked
		6.59 pH	6.64 pH	6.64 pH	6.39 pH	6.40 pH	6.71 pH	
Staphylococcus sureus	0	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-
	4	-	-	-	+	-	-	-
	24	-	-	-	+	-	-	-
Salmonella typhimurium	0	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-
	24	-	-	-	-	-	-	-
Salmonella enteritidis	0	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-
	24	-	+	-	-	-	-	-
Salmonella gallinarum	0	-	-	-	-	-	-	-
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	3	-	-	-	-	-	-	-
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Salmonella pullorum (19)	0	-	-	-	-	-	-	-
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Salmonella choleraesuis	0	-	-	-	-	-	-	-
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	4	-	-	-	-	-	-	-
	24	-	-	-	-	-	-	-

species of the Salmonellae was noted in puddings which had been allowed to stand at room temperature for 24 hours. Of the three species, *Salmonella pullorum* no. 19 and *Salmonella orienburg* both were present in the 12% sugar vanilla pudding and *Salmonella enteritidis* occurred in the 18% sugar vanilla pudding. None of the chocolate, butterscotch or 25% sugar vanilla puddings showed viable Salmonellae.

The survival of *Staphylococcus aureus* was noted in the chocolate pudding after storage at room temperature for 4 as well as 24 hours. Although the chocolate puddings prepared in this laboratory had the lowest pH of all puddings tested (mean of 6.39), this did not seem to inhibit bacterial growth. Cathcart and Merz reported (1942) that in chocolate and cocoa fillings and puddings, the growth of *Staphylococcus aureus* was inhibited, due to a lowered pH. It is interesting to note that in both the salad dressings and puddings, the Staphylococcus bacteria seem to be more resistant to the acid and/or heat conditions of the experiment.

Tanner (1944) has stated that sugar does not exert a preservative effect until the concentration reaches 25 grams in 100 milliliters. Results of this study indicate the possibility that an increase in the concentration of sugar in puddings might inhibit bacterial growth.

Apparently under the conditions of this experiment, the heat treatment used in the preparation of the puddings was effective in reducing the number of micro-organisms to a minimum. No evidence of growth of any of the bacteria was obtained when the product stood three hours or less at room temperature, or for up to 24 hours at refrigerator temperature.

Custards

There was no variation in the formula used in the stirred and baked custards. At the rate of heating used in this experiment, one cup of stirred custard made with egg solids was just thickened in 5 to 6 minutes. The temperature reached at the thickening point for both stirred and baked custards was 91° to 93° C. The thickening temperatures at other rates of heating were not determined. Previous reports on the use of egg solids suggested baked but not stirred custard as a safe use. BHNHE Bulletin No. 136 (1950). The findings of these experiments (Table 5) suggest that the temperature used to thicken egg solids in either baked or stirred custards is sufficient to destroy all pathogenic bacteria inoculated into the egg solids. Cathcart and others (1942) also reported that in an experimental study on custards, neither *Staphylococcus aureus* nor *Salmonella enteritidis* survived the cooking process.

SUMMARY

From the study made of the viability of food poisoning organisms inoculated into cooked salad dressing, it was concluded that not all Salmonellae and Staphylococci are destroyed at the pH of the basic formula. However, this acidity does not provide a favorable medium for growth. The heat treatment of 84° to 86° C. used in cooking the contaminated egg solids in salad dressing, was sufficient to destroy the food poisoning bacteria under the conditions of these tests.

The minimum temperature for thickening eggs in puddings prepared in this laboratory, was not sufficient to destroy all bacteria inoculated into egg solids. However, under the conditions of these experiments, the number of viable micro-organisms was reduced to a minimum and growth was inhibited in all cases for at least three hours. These puddings, like all cream fillings, may be potentially dangerous if contaminated egg, either fresh, frozen or dried, is used. Prompt refrigeration minimizes this danger.

At the temperature of 91° to 93° C., used in the preparation of the stirred and baked custards in these experiments, none of the inoculated bacteria remained viable. Custards could probably be considered a safe use for whole egg solids. The danger of food poisoning from the use of contaminated eggs in such products as puddings and custards would appear to be remote if these products are adequately heated and refrigerated. It is particularly important to avoid contamination after cooking since these products, unlike the acid salad dressings, do provide a favorable medium for bacterial growth.

The results of these experiments seem to indicate that conditions under which egg solids might safely be used in other products should be given further consideration.

BIBLIOGRAPHY

Cathcart, W. H., Godkin, W. J., and Barnett, G., Growth of *Staphylococcus aureus* in various pastry fillings. *Food Research,* 12:142 (1947)

Cathcart, W. H. and Merz, Albert, Staphlococci and Salmonella control in foods. III. Effect of chocolate and cocoa fillings on inhibiting the growth of Staphylococcus. *Food Research,* 7:96 (1942)

Cathcart, W. H., Merz, Albert, and Ryberg, R. E., Staphylococcus and Salmonella control in foods. IV. Effect of cooking bakery custards. *Food Research,* 7:100 (1942)

Conrad, R. M., Vail, G. E., Olsen, A. L., Tinklin, G. L., Green, J. W., and Wagoner, Charles, Improved dried whole egg products. Kansas State Agricultural Experiment Station *Bulletin* 64, (1948)

Coughlin, F. E. and Johnson, B., Gastroenteritis outbreaks from cream filled pastry. *American Journal of Public Health,* 31:245 (1941)

Dack, G. M., Food Poisoning. University of Chicago Press, Chicago, Illinois, 138 pp. (1943)

Edwards, P. R., Bruner, D. W., and Moran, A. B., The genus Salmonella: Its occurrence and distribution in the United States. Kentucky Experiment Station *Bulletin* 525, (1948)

Fidler, Wilfred, Personal communication. F. W. Stamper Co., Moberly, Missouri, May, (1951)

Goddard, V. R., Personal communication. Food and Nutrition Division, U.S.D.A., Washington, D.C., (1950)

Goresline, H. E., Dehydration of eggs. *Proceedings of the Institute of Food Technologists,* 4:70 (1943)

Gorseline, H. E., Kirby, M. H., Moser, R. E., Jr., Howe, M. A., Jr., and Drewniak, E. E., Pasteurization of liquid whole egg under commercial conditions to eliminate Salmonella. Poultry Branch, U.S.D.A., *Circular* 897, (1951)

Hinshaw, W. R. and McNeil, E., Salmonella infection as a food industry problem. *Advances in Food Research,* 3:209 (1951)

Johns, C. K., and Berard, H. L., Further bacteriological studies relating to egg drying. *Scientific Agriculture,* 25:551 (1945)

Lineweaver, Hans, and Feeney, R. E., Improving frozen and dried eggs. *Yearbook of Agriculture for 1950-1951,* p. 642 (1951)

McCullough, N. B., and Eisele, C. W., Experimental human Salmonellosis. I. Pathogenicity of strains of *Salmonella meleagridis* and *Salmonella anatum* obtained from spray-dried whole egg. *Journal of Infectious Diseases,* 88:278 (1951)

Priebe, E. W., Jr., Personal communication. Institute of American Poultry Industries, Chicago, Illinois, May (1953)

Proctor, B. E., Joslin, R. P., Nickerson, J. T. R., and Lockhart, E. E., Elimination of Salmonella in whole egg powder by cathode ray irradiation of egg magma prior to drying. *Food Technology,* 7:291 (1953)

Schneider, M. D., Investigation of Salmonella content of powdered whole egg with not more than two percent moisture content. IV. Bactericidal action of the pre-heater on Salmonella in liquid whole eggs. *Food Technology,* 5:349 (1951)

School lunch recipes cooking with dried whole eggs. Bureau of Human Nutrition and Home Economics. U. S. D. A. *Bulletin,* P A 136, (1950)

Solowey, Mathilde, The problem of bacteria in eggs. *Yearbook of Agriculture for 1950-1951*, p. 650 (1951)

Solowey, Mathilde, and Calesnick, E. J., Survival of Salmonella in reconstituted egg powder subjected to holding and scrambling. *Food Research*, 13:216 (1948)

Solowey, Mathilde, McFarland, V. H., Spaulding, E. H., and Chemerda, Cecilia, Microbiology of spray-dried whole egg. II. Incidence and types of Salmonella. *American Journal of Public Health*, 37:971 (1947)

Stewart, G. F., There's a future for good dried eggs. *U. S. Egg and Poultry Magazine*, 54:17 (June 1948)

Tanner, F. W., Microbiology of Foods. 2nd Edition, Garrard Press, Champaign, Illinois, 1196 pp. (1944)

Wethington, M. C., and Fabian, F. W., Viability of food-poisoning Staphylococci and Salmonellae in salad dressing and mayonnaise. *Food Research*, 15:125 (1950)

Whitford, Corinne, Pickering, Carmel, Summers, Katheryn, Weis, Adelia, and Bisbey, Bertha, The vitamin content of eggs as affected by dehydration and storage. University of Missouri Agricultural Experiment Station Research *Bulletin* 483, (1951)