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ASSURING SAFETY OF EGG YOLK-BASED SAUCES AND SALAD DRESSINGS

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Abstract

For many years, products prepared from raw shell eggs have been implicated in foodborne disease outbreaks. It is now known that there may be the possible presence of *Salmonella enteritidis* within the yolk of a small percentage of intact, USDA-graded shell eggs. Food microbiologists and public health authorities have named homemade mayonnaise, Caesar dressing, and Hollandaise and Béarnaise sauces as items that pose risks of a hazard if prepared from raw shell eggs. The safety of these products can be assured if the cook takes specific steps, as presented in this paper, to reduce any possible *Salmonella* spp. in raw eggs (egg yolks) to a safe level. This can be accomplished when cooks use a preparation method for egg yolks that includes the addition of acid and a pasteurization step that provides a 100,000-to-1 CFU/g (5D) *Salmonella* reduction before the acidified/pasteurized egg yolks are used in the preparation of these products. Recipe formulations, calculations, directions for preparation, and pH of final products are given.

Introduction

Raw eggs are a functional ingredient in many sauces and salad dressings. In the past, the FDA considered the contents of whole, uncooked shell eggs to be pathogen-free and did not consider the contents of fresh eggs to be a high-risk food. However, possible contamination of intact shell eggs by *S. enteritidis* was recognized in Europe and the United States during the latter 1980s when it became known that this pathogen could be transferred from the infected ovaries of laying hens to the egg yolk before the shell was formed. USDA grading of shell eggs does not detect the presence of this pathogen. Today, a small percentage of raw shell eggs are contaminated, perhaps 1 in 10,000. This is true throughout the U. S. Unfortunately, one cannot look at the intact shell egg and have any idea about its safety. Therefore, food microbiologists and public health authorities have named homemade mayonnaise, Caesar dressing and Hollandaise and Béarnaise sauces as items that pose risks of a hazard if prepared from raw shell eggs. However, the safety of these products can be assured if the cook takes specific steps as presented in this paper to reduce any possible *Salmonella* spp. in raw eggs to a safe level. This can be accomplished when cooks use a preparation method for egg yolks that includes pasteurization which provides the same 100,000-to-1 CFU/g (5D) *Salmonella* reduction, or greater than is specified for cooking hamburgers.

To prevent foodborne illness, public health authorities recommend: (1) using pasteurized intact shell eggs (available in only a few areas of the U.S.), (2) using commercial liquid egg products pasteurized according to USDA specifications (USDA 1969) that are normally only available

frozen, in large containers, (3) purchasing supplier-certified, salmonellae-free eggs (which are available from only a few suppliers), and (4) cooking eggs until all parts of the egg reach a temperature of at least 145F (63C) for 15 seconds according to the FDA 1995, 1997 Food Codes. (This really is not an adequate pasteurization.) None of these options are practical for a normal retail food operation preparing fresh sauces and dressings in small quantity.

The microbiological hazard can be eliminated if certain precautions are taken, such as those used in the commercial preparation of mayonnaise. Acid ingredients in mayonnaise, if in sufficient concentration or amount, can eliminate salmonellae from raw egg yolks if given an adequate amount of holding time at room temperature after manufacture. Federal regulations assume the presence of salmonellae in raw eggs used for salad dressings and require that commercially manufactured dressings such as mayonnaise and salad dressing made with unpasteurized eggs must have a pH of less than or equal to 4.1, an acetic acid level of the aqueous phase of greater than or equal to 1.4%, and a holding period of 72 hours before the product is shipped *(CFR Title 21 Part 101.100 and 169.140)*. These conditions were established to assure destruction of *Salmonella* and were based on studies of Wethington and Fabian *(1950)*. The use of unpasteurized eggs in mayonnaise or salad dressing by commercial manufacturers was discontinued in the early 1970s and they began using USDA-certified, pasteurized eggs. However, there still may be low contamination of these pasteurized products with low levels of *Salmonella* spp. Therefore, the acetic/citric acid level in these products remains critical. Commercial mayonnaise in the United States produced in accordance with the FDA Standard of Identity actually contains enough acid to destroy *Salmonella* spp. and inhibit the growth of other foodborne pathogenic bacteria such as *Listeria monocytogenes (Smittle, 1977; Glass and Doyle, 1991; Erickson and Jenkins, 1991; Radford and Board, 1993).*

This paper will describe a simple egg yolk pasteurization method that incorporates this acid-safety concept. Restaurant chefs and cooks in homes can use this method to assure the safety of sauces and dressings made from fresh egg yolks. This method can be used to prepare a few pasteurized egg yolks in advance for use in sauces and dressings throughout the day as well as for the immediate preparation of these items.

Method for Controlling Salmonellae Contamination in Egg-Based Sauces and Dressings

The simplest method for controlling microbial contamination and minimizing the risk of foodborne illness in a kitchen is the application of heat. This occurs when products are pasteurized. However, heating fresh eggs (whole or yolks) to temperatures sufficient to decrease microbial hazards for emulsified salad dressings and sauces has not been thought by cooks to be possible. This is because most cooks know that when eggs (whites and yolks) are heated above 150F (65.6C), the egg proteins solidify and become hard. When egg-thickened sauces are heated excessively, the emulsions break, and the sauces curdle and separate. Therefore, cooks attempt to keep the temperature of the sauces just slightly warm [110 to 120F (43.3 to 48.9C)] when these products are prepared. In the attempt to maintain the stability of the sauces, these sauces are held at temperatures of 110 to 115F (43.3 to 46.1C). These temperatures allow the growth of pathogenic bacteria such as *Salmonella* spp.

Cooks must understand the importance of acid and temperature in the preparation of egg-based sauces, mayonnaise, and Caesar dressing in order to prepare these items safely. The procedure is accomplished by diluting and acidifying the yolk of eggs and heating the mixture to a pasteurizing temperature [heating for a sufficient period of time necessary for a 100,000-to-1 CFU/g (5D) reduction]. This procedure ensures the destruction of vegetative cells of *Salmonella*

spp. and other pathogenic bacteria such as *L. monocytogenes* and *Escherichia coli* O157:H7. The method has been adapted from that described by McGee *(1990a, 1990b)*. Actually many formulated cookbook recipes for mayonnaise, Caesar dressing, Hollandaise and Béarnaise sauce include more than enough acid. However, the amount of acid in these foods is not recognized as a critical hazard control.

The first step is to recognize that if the egg yolk protein is mixed with an equal volume of water and from one-third to an equal volume of lemon juice or vinegar, the temperature at which coagulation of the egg yolk protein occurs is raised. When the egg yolk/acid mixture is heated to 150F (65.6C), vegetative pathogenic bacteria are reduced at least 100,000 to 1 CFU/g, while the egg yolk proteins have not been heated sufficiently to denature and coagulate because of the water dilution and acid. It is critically important that an accurate thermocouple thermometer (such as the *Atkins 33040 ™*) be used to measure the temperature of the mixture. Temperature measurement is necessary to ensure that the mixture is heated to 150F (65.6C) to assure safety, but not heated to temperatures above this point [approximately 180 to 190F (82.2 to 87.8C)] which cause the yolk proteins to coagulate.

The emulsifying capability of egg yolk is mainly related to its content of lecithin (about 1.22% of the yolk) *(Stadleman 1986)*. Lecithin is a phospholipid and is not affected by the acid/heat pasteurization process and remains an effective emulsifying agent in the pasteurized egg yolk/acid mixture.

Specific Procedures for Cold Oil Sauces

Mayonnaise and Caesar dressing are examples of cold oil sauces containing egg yolks. See recipe formulations for mayonnaise (Figure 1), as adapted from Bocuse and Metz *(1996)*, and Caesar dressing (Figure 2), as adapted from Rombauer and Becker *(1974)*.

Method for assuring destruction of *Salmonella* spp. in egg yolk. Place egg yolk(s) in a small, stainless steel bowl. (The container must be large enough so that it can allow the egg yolk/acid mixture to be stirred or whisked as it is heated.) Place the container containing the egg yolk/acid mixture in a pan or bowl of water (such as a small double boiler) that is at a simmering temperature of 180 to 190F (82.2 to 87.8C). Heat the yolk/acid mixture to a temperature of 150F (65.6C). This will take about 1 minute. The mixture must be stirred or whisked constantly and the temperature measured frequently by using a micro-tip thermocouple thermometer (such as the *Atkins 33040 ™*). Immediately remove the pan containing the yolk/acid mixture from the hot-water heat source. The yolk/acid mixture is now pasteurized and can be used in the preparation of mayonnaise and Caesar dressing.

Recipes for these products should be checked, or recipes provided in this paper should be used to assure that there is the correct amount of acidity. As a starting point, the standard of identity for vinegar is 5% acetic acid. The amount of citric acid in lemon juice (bottled or freshly squeezed) is 4.7%. A typical mayonnaise should be prepared with 1 raw egg yolk per 8 ounces of oil and the acid concentration should be 1.4% of the aqueous phase as recommended by the FDA *(CFR Title 21 Part 101.100)*.

The calculation for percent of water in the aqueous phase is as follows:

(total amount of acid / total amount of water) x 100 = % acid in water (aqueous) phase

Calculation for Amount of Acid in the Aqueous (Water) Phase for Mayonnaise
See Recipe of Figure 1.

Ingredients	Weight (grams)		Aqueous (water) phase (grams)
Egg yolks (3)	48	x 48% water*	23
Wine vinegar (2 Tbsp.)	30		30
Lemon juice (2 Tbsp.)	30		30
Water (2 Tbsp.)	30		30
		Total	113

*USDA Egg Grading Manual

In this formulation, there are 1.5 g acetic acid (based on 5% in 30 g vinegar) and 1.41 g citric acid (based on 4.7% in 30 g lemon juice), for a total of 2.91 g acid.

The calculation for percent acid in the aqueous phase is:

(2.91 g acid/113 g water) x 100 = 2.6% acid in aqueous phase. The final measured pH of this mixture is 3.5.

Calculation for Amount of Acid in the Aqueous (Water) Phase for Caesar Dressing
See Recipe of Figure 2.

Ingredients	Weight (grams)		Aqueous (water) phase (grams)
Egg yolk (1)	16	x 48% water	7.7
Wine vinegar (2-1/2 Tbsp.)	37.5		37.5
		Total	45.2

There are 1.875 g acetic acid (based on 5% in vinegar) in 37.5 g. wine vinegar.

The calculation for percent acid in the aqueous phase is:

(1.875 g acid/45.2 g water) x 100 = 4.15% acid in aqueous phase. The final measured pH of this mixture is 3.6.

Figure 1. QUALITY-ASSURED HACCP RECIPE PROCEDURES

Recipe Name: **Basic Mayonnaise**
Recipe #:
Production style: **Soup/Sauce**
Written by: Date:

Portion size (vol./wt.):
Number of portions:
Final yield (AS): 1 quart
Final pH = 3.5

Preparation time:
To be prepared by:
Supervisor:
SA/QA by: Date:

Group #	Ingred. #	Ingredients and Specifications	EP Weight %	Edible Portion (EP) (weight or volume)	
I.	1	Egg yolks (3)	6.10	1.69 oz.	(48.0 g)
	2	White wine vinegar (2 Tbsp.)	3.81	1.06 oz.	(30.0 g)
	3	Lemon juice (2 Tbsp.)	3.81	1.06 oz.	(30.0 g)
	4	Water (2 Tbsp.)	3.81	1.06 oz.	(30.0 g)
II.	5	Mustard, dry (2 teaspoons)	0.51	0.14 oz.	(4.0 g)
	6	Salt (1/2 teaspoon)	0.42	0.12 oz.	(3.3 g)
	7	Cayenne pepper (1/2 teaspoon)	0.18	0.05 oz.	(1.4 g)
III.	8	Vegetable oil* (3 cups)	81.35	22.57 oz.	(640.0 g)
		Total	100.00	27.75 oz.	(786.7 g)

Pre-preparation
1. Measure or carefully weigh all ingredients.

Preparation
2. Combine egg yolks, white wine vinegar, lemon juice, and water in small, stainless steel bowl. The container must be large enough so that it can allow the egg yolk/acid mixture to be stirred or whisked as it is heated.
3. Place the container containing the egg yolk/acid mixture in a pan or container of water (such as a small double boiler) that is at a simmering temperature of 180 to 190F (82.2 to 87.8C). Heat the yolk/acid mixture to a temperature of 150F (65.6C). ***This will take about 1 minute.*** The mixture must be stirred or whisked constantly and the temperature measured frequently by using a tip-sensitive thermocouple thermometer (such as the *Atkins 33040*). The thermocouple can be taped to the wire whip to give continuous temperature as the mixture is stirred. When a temperature of 150F (65.6C) is reached, immediately remove the pan containing the yolk/acid mixture from the hot-water heat source. Cool the egg mixture to room temperature [<80F (<27C)].
[The pasteurized egg yolks are very stable at this point and can be stored for 7 days at 41F (5C) if you want to make the batch larger and then store it. The pH of this mixture is 3.5.]
4. Place the pasteurized, acidified yolk mixture in a stainless steel mixer bowl. Add dry mustard, salt, and cayenne pepper.
5. Either an electric mixer or a wire whip can be used to create the mayonnaise emulsion. Begin beating with French whip, or if a mixer is used, turn it to high speed and very slowly, almost teaspoon by teaspoon, begin adding oil. When the emulsions forms, oil can be added more rapidly.
6. Continue beating until all the oil has been added. The mayonnaise emulsion will become quite thick. (It can be thinned, if desired, by adding a small amount of wine vinegar or lemon juice.)
7. Adjust seasoning. If necessary, adjust viscosity with the addition of a small amount of vinegar or lemon juice.

Storage
8. Place mayonnaise in clean, sanitized storage container. Label and date product. By government standard, this product does not require refrigeration for safety. For quality, store in refrigeration unit at 41F (5C) or less. The shelf life will depend on mold contamination during mixing, but should be at least 4 weeks.

Leftovers
9. For quality, do not add fresh product to old.

Note:** ***If olive oil is used, the mayonnaise should be used at once. It cannot be stored under refrigeration because olive oil will crystallize or solidify at refrigeration temperatures and the mayonnaise emulsion will "break" and separate.

Ingredients that could produce possible allergic reactions: Egg yolk. Sulfites, if bottled lemon juice is added.

Process step #	Start food ctr. temp., F	Thickest food dimension (in.)	Container size H x W x L (in.)	Cover Yes/No	Temp. on/ around food	End food ctr. temp., F	Process step time, hr./min.

Figure 2. QUALITY-ASSURED HACCP RECIPE PROCEDURES

Recipe Name: **Caesar Dressing**
Recipe #:
Production style:
Written by: Date:

Portion size (vol./wt.):
Number of portions:
Yield: 1/2 cup
Final pH = 3.6

Preparation time:
To be prepared by:
Supervisor:
SA/QA by: Date:

Group #	Ingred. #	Ingredients and Specifications	EP Weight %	Edible Portion (EP) (weight or volume)	
I.	1 2	Egg yolk (1) White wine vinegar (1 Tbsp.)	9.5 8.9	0.56 oz. 0.53 oz.	(16.0 g.) (15.0 g.)
II.	3 4 5 6 7 8 9	Vegetable oil (1/2 cup) White wine vinegar (1 1/2 Tbsp.) Salt (3/4 teaspoon) Sugar (1/2 teaspoon) Dry mustard (1/4 teaspoon) Garlic powder (1/8 teaspoon) Freshly ground black pepper (1/8 teaspoon)	63.4 13.3 2.9 1.2 .3 .2 .2	3.77 oz. 0.79 oz. 0.17 oz. 0.07 oz. 0.02 oz. 0.10 oz. 0.01 oz.	(107.0 g.) (22.5 g.) (4.9 g.) (2.0 g.) (0.5 g.) (0.4 g.) (0.4 g.)
		Total	100.0	5.95 oz.	(168.7 g.)

Pre-preparation
1. Measure or carefully weigh all ingredients.

Preparation
2. Combine egg yolk with white wine vinegar in small, stainless steel bowl. The container must be large enough so that it can allow the egg yolk/acid mixture to be stirred or whisked as it is heated.
3. Place the container containing the egg yolk/acid mixture in a pan or container of water (such as a small double boiler) that is at a simmering temperature of 180 to 190F (82.2 to 87.8C). Heat the yolk/acid mixture to a temperature of 150F (65.6C). ***This will take about 1 minute.*** The mixture must be stirred or whisked constantly and the temperature measured frequently by using a tip-sensitive thermocouple thermometer (such as the *Atkins 33040*). The thermocouple can be taped to the wire whip to give continuous temperature as the yolk/acid mixture is stirred. When a temperature of 150F (65.6C) is reached, immediately remove the pan containing the yolk/acid mixture from the hot-water heat source. Cool the mixture to room temperature [<80F (<27C)]. ***[The pasteurized egg yolk/acid mixture is very stable at this point and can be stored for 7 days at 41F (5C) if you want to make the batch larger and then store it. The pH of this mixture is 3.6.***
4. Place the pasteurized, acidified yolk mixture in a stainless steel bowl. Add vegetable oil, white wine vinegar, salt, sugar, dry mustard, garlic powder, and pepper.
5. Beat with a French whip to create a temporary salad emulsion.
6. Adjust seasoning.

Use and Storage
7. **For immediate use**: Pour dressing over romaine lettuce or a combination of romaine, Bibb lettuce and iceberg lettuce that has been washed and then rinsed, dried and torn. Sprinkle with Parmesan cheese. Toss salad. Garish with garlic croutons and (if desired) fillets of anchovy.
8. Dressing can be stored in a clean, sanitized container. Label and date product. Store in refrigeration unit at 41F (5C) or less for quality. (pH 3.6 assures safety.) The shelf life will depend on mold contamination during mixing, but should be at least 4 weeks.

Leftovers
9. For quality, do not add fresh product to old.

Ingredients that could produce possible allergic reactions: Egg yolk. Anchovies, if used.

Process step #	Start food ctr. temp., F	Thickest food dimension (in.)	Container size H x W x L (in.)	Cover Yes/No	Temp. on/ around food	End food ctr. temp., F	Process step time, hr./min.

Hot Butter Sauces

Hollandaise and Béarnaise sauces are examples of hot butter sauces. In many ways, these products can be considered as hot mayonnaise. They are butter in water emulsions thickened by slightly heated egg yolks. The amount (percent) of acid in the aqueous phase of the Hollandaise sauce and Béarnaise sauce recipes, as adapted from Gisslen *(1989)*, shown in Figures 3 and 4, are calculated below.

Calculation for Amount of Acid in the Aqueous (Water) Phase for Hollandaise Sauce
See Recipe of Figure 3.

Ingredients	Weight (grams)		Aqueous (water) phase (grams)
Egg yolks (12)	192	x 48% water	92.2
Lemon juice (6 Tbsp.)	90		90.0
Water (2 Tbsp.)	30		30.0
		Total	212.2

There is 4.23 g acid (based on 4.7% citric acid in lemon juice).

The calculation for percent acid in the aqueous phase is:

(4.23 g acid/212.2 g water) x 100 = 4.15% acid in aqueous phase. The final measured pH of the mixture is 3.8.

Calculation for Amount of Acid in the Aqueous (Water) Phase for Béarnaise Sauce
See Recipe of Figure 4.

Ingredients	Weight (grams)		Aqueous (water) phase (grams)
Egg yolks (12)	192	x 48% water	92.2
White wine vinegar (3/4 cup - *reduced*)	180		180.0
		Total	272.2

There is 9.0 g acid (based on 5% acetic acid in 180 g white wine vinegar).

The calculation for percent acid in the aqueous phase is:

(9.0 g acid/272.2 g water) x 100 = 3.3% acid in aqueous phase. The final measured pH of the mixture is 4.2.

In the preparation of Béarnaise sauce, the wine vinegar is reduced by 3/4. In this process, some of the acid is lost. Hence, the final pH is a little higher (pH 4.2). This is still an absolutely safe, stable sauce.

Figure 3. QUALITY-ASSURED HACCP RECIPE PROCEDURES

Recipe Name: **Hollandaise Sauce** Recipe #: Production style: **Soup/Sauce** Written by: Date:	Portion size (vol./wt.): Number of portions: Yield: 1 quart Final pH = 3.8	Preparation time: To be prepared by: Supervisor: SA/QA by: Date:

Group #	Ingred. #	Ingredients and Specifications	EP Weight %	Edible Portion (EP) (weight or volume)	
I.	1 2 3	Egg yolks (12) Lemon Juice (6 Tbsp.) Water (4 Tbsp.)	15.2 7.2 4.8	6.8 oz. 3.0 fl. oz. 2.0 fl. oz.	192.0 g. 90.0 g. 60.0 g.
II.	4	Butter, clarified*	72.4	2.0 lb.	908.0 g.
III.	5 6	Salt (1/2 teaspoon) Cayenne pepper (1/2 teaspoon)	0.3 0.1	0.12 oz. 0.05 oz.	3.3 g. 1.4 g.
		Total	100.0		1254.7

Pre-preparation
1. Measure or carefully weigh all ingredients.

Preparation
2. Combine egg yolks, lemon juice, and water in a medium-sized, stainless steel bowl. Using a wire whisk, beat well.
3. Place the container containing the egg/yolk acid mixture in a pan or bowl of water (such as a small double boiler) that is at a simmering temperature of 180 to 190F (82.2 to 87.8C). Continue beating the yolk/acid mixture and heat to a temperature of 150F (65.6C). The mixture must be stirred or whisked constantly and the temperature measured frequently by using a micro-tip thermocouple thermometer (such as the *Atkins 33040*). Immediately remove the pan containing the yolk/acid mixture from the hot-water heat source. The mixture should be creamy.
4. Slowly and gradually beat in the clarified butter. Add the butter drop by drop at first to disperse the butter oil and create an emulsion. As the emulsion forms, the butter can be added in larger amounts.
5. When all the butter has been added, adjust seasoning with salt and cayenne pepper. If necessary, thin the sauce with a few drops of warm water. The final pH is 3.8.

Storage
6. Keep warm [100 to 120F (43.3 to 48.9C)], not hot, for service. This Hollandaise sauce can be held at 100 to 120F (43.3 to 48.9C) as long as the quality allows. There is no food safety problem because of the pH.

Leftovers
7. For quality, do not add fresh product to old.

Note:** ***To clarify butter for this recipe, place 2 1/2 lb. butter in heavy sauce pan. Melt butter over moderate heat. Skim froth from the surface. Carefully pour off clear, melted butter into another container, leaving the milky liquid and salt (if salted butter was used) on the bottom of the pan.

Ingredients that could produce possible allergic reactions: Egg yolk. Sulfites, if bottled lemon juice is added.

Process step #	Start food ctr. temp., F	Thickest food dimension (in.)	Container size H x W x L (in.)	Cover Yes/No	Temp. on/ around food	End food ctr. temp., F	Process step time, hr./min.

Figure 4. QUALITY-ASSURED HACCP RECIPE PROCEDURES

Recipe Name: **Béarnaise Sauce** Recipe #: Production style: **Soup/Sauce** Written by: Date:	Portion size (vol./wt.): Number of portions: Yield: 1 quart pH = 4.2	Preparation time: To be prepared by: Supervisor: SA/QA by: Date:

Group #	Ingred. #	Ingredients and Specifications	EP Weight %	Edible Portion (EP) (weight or volume)	
I.	1. 2. 3.	White wine vinegar (1 cup) Shallots, chopped (2 oz.) Tarragon leaves (2 teaspoons)	16.97 4.01 0.17	8.47 oz. 2.00 oz. 0.08 oz.	(240.0 g.) (56.7 g.) (2.4 g.)
II.	4	Egg yolks (12)	13.58	6.77 oz.	(192.0 g.)
III.	5	Butter, clarified*	64.20.	2.00 lb.	(908.0 g.)
IV.	6 7 8	Fresh ground pepper (1/4 teaspoon) Salt (1/2 teaspoon) Cayenne pepper (1/2 teaspoon)	0.05 0.23 0.10	0.02 oz. 0.12 oz. 0.05 oz.	(0.7 g.) (3.3 g.) (1.4 g.)
V.	9 10	Parsley , fresh chopped (2 Tbsp.) Tarragon (1 teaspoon)	0.52 0.17	0.26 oz. 0.08 oz.	(7.4 g.) (2.4 g.)
		Total	100.0	49.85 oz.	(1414.3 g).

Pre-preparation
1. Measure or carefully weigh all ingredients.

Preparation
2. Combine the shallots, vinegar, and tarragon in a saucepan and reduce by three-fourths. Remove from heat and cool slightly. Strain, if you wish.
3. Combine the vinegar mixture with egg yolks in a medium-sized, stainless steel bowl. Using a wire whisk, beat well.
4. Place the container containing the egg/yolk acid mixture in a pan or bowl of water (such as a small double boiler) that is at a simmering temperature of 180 to 190F (82.2 to 87.8C). Continue whisking the yolk/acid mixture and heat to a temperature of 150F (65.6C). The mixture must be stirred or whisked constantly and the temperature measured frequently by using a micro-tip thermocouple thermometer (such as the *Atkins 33040*). Immediately remove the pan containing the yolk/acid mixture from the hot-water heat source. The mixture should be creamy. Cool slightly.
5. Slowly and gradually beat the clarified butter into the yolk acid. Add the butter drop by drop at first to disperse the butter oil and create an emulsion. As the emulsion forms, the butter can be added in larger amounts. (If the sauce becomes too thick to beat before all the butter is added, beat in a little warm water.)
6. Adjust seasoning with salt and cayenne pepper. If necessary, thin the sauce with a few drops of warm water. Mix in the parsley and tarragon. The final pH is 4.2.

Storage
7. Keep warm [100 to 120F (43.3 to 48.9C)], not hot, for service. This Béarnaise sauce can be held at 100 to 120F (43.3 to 48.9C) as long as the quality allows. There is no food safety problem because of the pH.

Leftovers
8. Do not add fresh product to old.

Note:** ***To clarify butter for this recipe, place 2 1/2 lb. butter in heavy sauce pan. Melt butter over moderate heat. Skim froth from the surface. Carefully pour off clear melted butter into another container, leaving the milky liquid and salt (if salted butter was used) on the bottom of the pan.

Ingredients that could produce possible allergic reactions: Egg yolk.

Process step #	Start food ctr. temp., F	Thickest food dimension (in.)	Container size H x W x L (in.)	Cover Yes/No	Temp. on/ around food	End food ctr. temp., F	Process step time, hr./min.

Acid - pH Control

The question can be asked, "Is a $500.00 pH meter needed to check each batch of egg-based sauce to assure safety?" The answer is, "Absolutely not!" If the recipe formula is followed, the pH and safety is assured. If one wants a simple test, pH strips are available from companies such as EM Science (Gibbstown, NJ) that are sufficiently precise to show that an adequate pH was reached.

Additional Information Regarding the Microbiology of Salad Dressings

Even before the advent of knowledge concerning the possible presence *Salmonella enteritidis* in the yolks of freshly laid eggs, there was the concern that mayonnaise, salad dressings, and some egg based sauces such as Hollandaise sauce and Béarnaise sauce could be potentially hazardous because of their link to foodborne illness outbreaks.

In 1950, Wethington and Fabian reported research studies that demonstrated that the growth and viability of *Salmonella* spp. and *Staphylococcus aureus* in salad dressing and mayonnaise was related to the acetic acid content of these products. This research was used to establish the U. S, Food and Drug Administration regulations and Standards of Identity for Mayonnaise and Salad Dressing *(CFR Title 21, Parts 101.100 and 169.140).*

Mayonnaise, as described and defined by the FDA Standard of Identity, is an emulsified, semisolid food prepared from vegetable oil(s), one or more acidifying ingredients (vinegar, lemon and/or lime juice), egg yolk-containing ingredients, and one or more optional ingredients that include salt, nutritive carbohydrate sweeteners, spice, monosodium glutamate, sequesterants, and crystallization inhibitors. Mayonnaise contains not less than 65% by weight of oil.

Salad dressing, as described and defined by the FDA Standard of identity, is an emulsified semisolid food prepared from vegetable oil(s), one or more acidifying ingredients (vinegar, lemon and/or lime juice), egg yolk-containing ingredients, starch paste prepared from a food starch, and one or more optional ingredients that include salt, nutritive carbohydrate sweeteners, spices, monosodium glutamate, stabilizers, and thickeners. Salad dressing contains not less than 30% by weight of oil.

The acid present in mayonnaise and salad dressings also control other pathogens that may occur in these products. In 1977, Smittle reviewed the factors involved in microbiological content and safety of commercial salad dressings and mayonnaise produced in the U.S. Acetic acid (from vinegar) in these commercial products has the major preservative effect due to its bactericidal effect on vegetative cells of pathogenic microorganisms, especially food pathogens. Salt and sugar have minor effects. Smittle reported that both *Salmonella* and *S. aureus* are killed and organisms die out at a pH of 4.1 or less (0.25% acetic acid based on total weight). The acetic acid levels (based on total weight) used by major producers, 0.31 to 0.32% for mayonnaise and 0.90 to 0.928% for salad dressing are effective in destroying salmonellae and staphylococci. Smittle concluded that commercially-produced, undiluted mayonnaise or salad dressing will not support the growth of *Salmonella* spp., *S. aureus, Clostridium botulinum, Clostridium. perfringens, Streptococcus viridans, Shigella flexneri, or Bacillus cereus.*

A study by Perales and Garcia *(1990)* reported the viability and growth of *Salmonella* spp. in homemade mayonnaise prepared with whole eggs. Samples of the mayonnaise acidified with lemon juice or wine vinegar to pH 5, 4.5 or 3.6 were inoculated with *S. enteritidis*. The samples were incubated (stored) at 39.2, 75.2, or 95.4F (4, 24, or 35C). The bactericidal effect of vinegar (acetic acid) was found to be greater than that of lemon juice (citric acid). Low temperature

incubation 39.2F (4C) provided some protection to the salmonellae against the bactericidal effects of the organic acids. It was recommended that vinegar be used as an acidulant for homemade mayonnaise, the pH of the final product should be 3.6 to 4.0, and that the mayonnaise receive unchilled storage for some hours or days before consumption. The antimicobial activity of organic acids is largely due to the undissociated molecules. At pH values of 3.6 to 4.1, there is more acetic acid in the undissociated acid form than undissociated citric acid at this same pH range, thus acetic acid is a more effective bactericide *(Radford and Board, 1993).*

In 1995, Lock and Board reported that when homemade mayonnaise was prepared from the yolks of eggs artificially contaminated with *S. enteritidis*, the fate of the organism was both inoculum-concentration and temperature-dependent. Storage at low temperatures appeared to protect the salmonellas against the effects of the organic acid. However, these principles did not apply to mayonnaise prepared with lemon juice. In this case, the fate of *S. enteritidis* appeared to be largely independent of temperature, but was dependent upon inoculum size (amount of contamination). For example, in mayonnaise prepared from eggs inoculated with 10^2 to10^5 organisms per air cell, *S. enteritidis* was not detected at any time during a 6-day storage period. However, at higher inoculum levels (10^6 to 10^9), the populations in mayonnaise remained constant when stored at 39.2F (4C) and increased slightly when the mayonnaise was stored at 68F (20C). Fortunately, the contamination of egg yolks with *S. enteritidis* is believed to be less than 10^5 *(Rhorer, 1998).*

Clostridium botulinum and *C. perfringens* do not survive in mayonnaise below pH 4.7 (acetic acid) or at water activities below 0.95 commonly found in these products. The low aw of these products is also sufficient to prevent the spore outgrowth of *B. cereus (Radford and Board, 1993).* Glass and Doyle *(1991)* reported that *Listeria monocytogenes* will not grow in a properly acidified (pH less than 4.1) reduced-calorie mayonnaise containing 0.7% acetic acid in the aqueous phase).

Spoilage of Mayonnaise and Salad Dressing

For quality reasons, leftover mayonnaise, salad dressings, and egg sauces should not be added to freshly prepared mayonnaise, salad dressings, and sauces. Acidic conditions in combination with other factors such as reduced water activity in mayonnaise and salad dressing prevent the growth of most microorganisms commonly associated with food spoilage. However, spoilage of these products does occur as a result of the growth of lactobacilli, bacilli, and yeasts *(Kurtzman, 1971; Smittle and Flowers, 1982; Meyer et al., 1989).* Spoiled products exhibit off flavors and dark button-like colonies (indications of yeast colony formation) may be present on the surface. However, the pH range for spoiled mayonnaise and salad dressings is from 3.6 to 4.1, which is similar to the 3.7 to 4.2 pH range for unspoiled commercial products. Thus, the safety of spoiled commercial products is maintained.

Use of Mayonnaise and Salad Dressing in Salads and Sandwiches

Properly acidified salad dressing and mayonnaise used to prepare salads and sandwiches have an inhibitory effect on pathogenic bacterial growth in these products which is attributed to their acetic/citric acid content. Contrary to popular belief these products, when added to salads or sandwiches will not increase spoilage or public health hazards, but may actually retard spoilage and growth of pathogenic bacteria when compared to products to which there has been no addition. At the same time, microbial stability of the dressing itself decreases due to the dilution of the other ingredients. In other words, there is an equilibration of the total combined system.

Doyle et al. *(1982)* tested the ability of *S. aureus* and *Salmonella typhimurium* to survive and/or multiply in meat salads prepared with different proportions of mayonnaise stored at 39.2, 68, or 89.6F (4, 20 or ° C). The presence of mayonnaise in the meat salads retarded the growth of these food pathogens and extended shelf-life. However, it was recommended that the presence of mayonnaise should not be considered as a substitute for refrigeration.

Simmons et al. *(1979)* formulated an egg salad with acidic salad dressing that would not support salmonellae growth when the acidic salad was stored at 72F (22C). The egg salad inoculated with over 6,000 colony forming units of *Salmonella senftenberg* per milliliter was free of the organism after 60 hours when held at 72F (22C). The shelf life of the egg salad was determined to be in excess of 5 weeks if refrigerated at 41F (5C). The pH of this egg salad was 4.28.

Summary

When a chef understands the principles of food pasteurization and how to follow a standardized recipe, it is a simple matter to make absolutely safe, gourmet signature sauces. This technology has many added applications that will be presented in future publications.

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