To the Graduate Council:

I am submitting herewith a thesis written by Yih-Chuan Wu entitled "The Evaluation of Stabilizers Used in Cottage Cheese." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology and Science.

W. W. Overcast, Major Professor

We have read this thesis and recommend its acceptance:

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Graduate Studies and Research

THE EVALUATION OF STABILIZERS USED IN COTTAGE CHEESE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee

Yih-Chuan Wu

December 1974

ACKNOWLEDGMENT

The author wishes to express his deepest gratitude to Dr. W. W. Overcast for his valuable and patient guidance and encouragement during the period of the graduate study. Appreciation is expressed to Dr. H. O. Jaynes and Dr. J. L. Collins for serving on the graduate committee and for their helpful suggestions. Special thanks are due to the members of the sensory panel for their participation and suggestions.

Appreciation is also expressed to Mr. Ralph Terry, Mrs. Anne Helms, for their assistance with the laboratory work; to Mr. John North, manager of Pet Dairy Division, Knoxville for his help and encouragement; and to Mrs. Lib Lynch for typing the manuscript and preparing the rough draft.

Deepest appreciation is expressed to the author's parents and in-laws for encouragement; and his loving wife, Pei-Yi, for her patience, understanding and encouragement throughout the course of graduate study.

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ABSTRACT

Seven stabilizers for dressings in cottage cheese were secured from 5 companies and evaluated. Homogeneity and viscosity of the dressing were determined. The creamed cottage cheese was evaluated by a competent taste panel.

The homogeneity of dressing was improved and viscosity of the dressing was also increased by the addition of stabilizer. The stabilizer was a remarkable factor to change the rheological properties of the dressing by increasing the viscosity.

The judgement of the sensory panel indicated that No. 7 stabilizer was significantly inferior to the other six stabilizers. The judgement also showed that the acceptance of creamed cottage cheese with stabilizer was preferred to the creamed cottage cheese without stabilizer.

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CHAPTER I

INTRODUCTION

Over the past 40-50 years, many hydrophilic colloids have come into wide use in the food industry. The primary purpose of using hydrophilic colloids has been to control the texture, to produce smoothness in body, to retard or reduce ice crystal growth during storage, water control, prevention of settling and for emulsification (7, 28). As defined by Blanshard (9), this group of hydrocolloid substances which have the property of significantly and usually changing a variety of important physical parameters in food systems, are called stabilizers. Other properties of the stabilizer used in foodstuffs were modification of the water binding capacity, reduction of the evaporation rate, modification of ice crystal formation, regulation of rheological properties, suspension of insoluble particles and stabilization of foam emulsion (7, 9, 13).

In the manufacture of creamed cottage cheese, a stabilizer is needed to contribute a creamy consistency to the cottage cheese dressing, keep the curd uniformly distributed and prevent the buildup of foam as the dressing is blended with the curd. It also improves the flavor of the cheese and aids in the production of high quality creamed cottage cheese (26, 34).

No two creamed cottage cheese operations are exactly the same. There are wide variations in equipment types, plant layout, ingredients

used, fat content, as well as difference in processing and incubation temperature and homogenization pressure (12, 34). Ideally, a cottage cheese stabilizer should be selected carefully and should produce a creamy consistency to the cottage cheese with an appealing flavor. However, stabilizers can be the source of undesirable flavor and texture. Among the stabilizer substances which are permitted and used, either singly or in combination, are gelatin, agar, algin, locust bean gum, gum tragacanth, carrageenan, furcellaran, lecithin, pectin, CMC (sodium carboxymethylcellulose) and cellulose gum (14, 15).

The present study was conducted to evaluate stabilizers which were commonly used for cottage cheese in the United States. Acceptance of the cottage cheese flavor was evaluated by using a sensory panel to score samples with hedonic scale by the multiple comparison. The sensory panel was screened by a triangle test to evaluate the ability and consistency of panelist. Research data were analyzed by statistical principles and may provide evidence for the use of these stabilizers in cottage cheese.

CHAPTER II

LITERATURE REVIEW

I. DEFINITION AND CLASSIFICATION OF STABILIZER

From a functional point of view, Blanshard (9) defined the stabilizers as the groups of hydrocolloid substance which have the property of significantly and usually changing a variety of important physical parameters in food systems. In addition to the natural plant polysaccharides such as carrageenan, agar, algin, pectin and starch, the group of stabilizers included proteins such as gelatin and casein, chemical derivatives of cellulose and starch such as methylcellulose, CMC (sodium carboxymethylcellulose) and dextrans, completely synthetic chemical products such as polyvinylpyrrolidone (PVP) (7, 14), and microbial gum such as xanthan (28).

II. THE STRUCTURE OF HYDROCOLLOID

Most of hydrocolloids were polymeric substances made up of identical or related units, with building blocks of D-glucose, D-mannose, or D-glucuronic acid residues. These residues were often associated in nature with metallic cations such as calcium, potassium, or magnesium bound to the carboxyl groups (14, 28). With cellulose and its derivatives, glucose units were joined by a 1-4 linkage in the beta position. The starches consisted of two components, amylose and amylopectin. Glucose units in the amylose were joined by the 1-4

linkage in the alpha position. Chains of glucose linked by alpha 1-4 linkages in the amylopectin were joined to each other by 1-6 linkage in the alpha position. In pectin, units of galacturonic acid were linked by alpha 1-4 glycosidic linkages. Most of the carboxylic acid groups in pectin were esterified with methanol. Alginic acid was a polyuronide comprising 1,4-linked D-mannuronic and L-guluronic acid units. Carrageenan, agar, and furcellaran, extracted from red algae, had a common composition of 3,6-anhydro-D-galactose and D-galactopyranose residues with the sulfate attached at the carbon 2, carbon 4, and carbon 6 positions (14, 22, 28).

The seed extracts, locust bean gum and guar gum, were a galactomannose polymer composed of a straight chain of D-mannose with a side chain of D-galactose on different positions. The natural plant exudates had complex structure and generally consisted of various sugar components in a multitude of structural shapes and sizes (14, 15).

The important elements in the structure which contribute to the behaviour of a hydrocolloid were the building block of pyranose ring, such as D-glucose, D-mannose and D-galactose residues, and the character of the linkage between the units in the biopolymer which affected the comformation of the structure and stability of the material (9).

III. THE PHYSICAL PROPERTIES OF HYDROCOLLOID

When hydrocolloids were dissolved in water, hydroophilic groups promoted the formation of hydrogen bonding, and as a result the hydrogen bonding reduced the freedom of molecular motions. Because of the polar

character of OH dipoles in water molecules, hydrogen bonding was encouraged. Thus hydrocolloid surfaces were surrounded by a layer of water molecules (9). Arbuckle (7) stated that the basic role of hydrocolloids in stabilized products was to absorb and hold large amounts of unbound water. In such a way, hydrocolloids reduce the amount of free water in ice cream mix by binding it as water of hydration or by immobilization within a gel structure. The most outstanding physical properties of hydrocolloids are given below.

Dispersibility

Dispersibility was one of the common problems of hydrocolloids. When hydrocolloids were dispersed into water carelessly, a form of lumps or gel was formed, which were wet on the outside, but dry or gel-like in the center. These particles were in the colloidal size range and were very difficult to break up and dissolve and no setting occurred in such a situation. The technique which was commonly used was adding the hydrocolloids slowly with maximum agitation and premixing the hydrocolloids with other dry ingredients in the formula before adding to the water or other liquid (14, 15, 29).

Solubility

By definition, hydrocolloids were soluble in water but had a limited solubility in alcohol and other organic solvents. The degree of solubility varied with the temperature and the pH of solution. Most of the hydrocolloids were used at less than 0.5 percent, because the ability of a small concentration to absorb and hold large amounts of water. An

excess amount of hydrocolloids made solubility difficult, made the products too viscous and imparted a sticky or gummy body (14, 28).

Viscosity

Apparent viscosity is one of the important functions of the hydrocolloids used in liquid and semisolid foodstuffs. The term viscosity is reserved for Newtonian solutions. When dissolved in water, hydrocolloids produce solutions or dispersions which are non-Newtonian. In the dairy industry, the term viscosity is mostly accepted for general use when in fact the term apparent viscosity should be applied. Therefore the term viscosity will be used in this study. The viscosities imparted by hydrocolloids were affected by many factors, such as concentration, temperature, degree of dispersion, electrical charge, previous thermal treatment and the presence or absence of other lyophilic colloids. The property of viscosity-producing of hydrocolloids was responsible for other functional effects such as emulsification, stabilization, suspension and related phenomena. Since hydrocolloids were mostly long-chain polymers, the molecular breakdown caused by cleavage of molecular bonds resulted in the reduction of viscosities of solutions. In general, the low viscosity-producing hydrocolloids were more stable than the high viscosity-producing hydrocolloids (7, 13, 14, 15).

Gelation

Hydrocolloids combined with the water present form a gel. The gel structure was a liquid-solid system and exhibited properties of both solids and liquids. Gelation was one of the advantages used in the food

industry to improve the body of the products, inhibit the formation of large ice crystals and contribute to the firmness in body of frozen products. Only a comparatively few gums have the ability to form gel. The three most important gel-forming hydrocolloids are gelatin, pectin and starch. The seaweed extracts (agar, algin, carragennan and furcellaran) also make up important gelling materials used in foods (14, 15, 24).

Emulsification, Stabilization and Suspension

Hydrocolloids have been used as emulsifiers, stabilizers and suspending agents in foods since ancient times. There are two types of emulsions--the oil-in-water type and water-in-oil type. The general properties of hydrocolloids affected primarily of the oil-in-water type emulsions. Emulsifiers are extremely important in food products such as milk, butter, cheese, ice cream and mayonnaise. A good emulsifier must have both strong lipophilic and hydrophilic properties; thus one portion of hydrophilic molecule dissolves in the water phase while the other portion, the lipophilic molecule, dissolves in the oil phase, and the main chains form bridges which keep both phases in position and thereby emulsified. Hydrocolloids are not true emulsifiers, they act as emulsion stabilizers or protectors by increasing the viscosity of the aqueous phase (5, 7, 8, 14, 15).

Many hydrocolloids such as carrageenans can be used to suspend the solid particles by virtue of their thickening effect. In suspension, the surfaces of the suspended particles were covered by hydrocolloids

and lost their normal surface. Thus, a protective colloid was formed which had the ability to connect the two phases and thereby stabilized the suspension (13, 15).

IV. THE USAGE OF STABILIZERS IN FOODSTUFFS

The use of hydrocolloids as food additives was basic to their functional properties. In the selection of hydrocolloids to be used, many factors had to be considered rather than just the required functional property (15, 24). Generally, the use of hydrocolloids included the following categories.

Modification of the Water Binding Capacity

A small amount of hydrocolloids had the ability to absorb and hold large amounts of water and reduced the mobility of the water. In food application, hydrocolloids exercised a profound effect on the water-binding capacity. Many foodstuffs may contain a relatively large amount of protein, carbohydrates and lipids with their hydrophilic groups, such as milk and milk products containing milk protein, fat, lecithin, phosphates and citrates, in practice these groups had only a little effect on the water (7, 9).

Reduction of the Rate of Evaporation

Hydrocolloids bind with the water to form gel structure. In such a way, hydrocolloids bind the free water as water of hydration or immobilizing it within a gel structure and thus reduced the rate of water loss. In a gel the evaporation rate was governed by the diffusion

of water through the gel to the evaporating surface. The diffusion coefficient was decreased with decreasing moisture content. The addition of hydrocolloids could result in a reduction of the rate of evaporation (5, 7, 9).

Regulation of Rheological Properties

The addition of hydrocolloids could modify the fluid properties of the products and further influence the mouthfeel and the textural properties of products (13). Hydrocolloids bind the water to form a gel structure by introducing pseudoplasticity and composing a sparely cross-linked network of longated chain-like polymeric molecules which entrapped the liquid phase. This character of regulation of rheological properties was considered to operate principally by increasing the viscosity (7, 9, 29).

Suspension of Insoluble Particles

The suspension of particles and the protection of colloids was a further application of hydrocolloid to beverages such as soft drinks and fruit juice drinks. Many hydrocolloids have been used to suspend cocoa solids by virtue of their thickening effect, such as chocolate milk and chocolate syrups (7, 14, 15). When dissolved in water, hydrocolloids attracted the water molecules strongly and immobilized them. The particles of suspension were formed into a flock, and resulted in a delicate solid-like structure entrapped in the suspension. Thus hydrocolloids were used as a suspension agent for imparting stability to a food, structure and for preventing sedimentation (7, 13).

Stabilization of Foams and Emulsions

Hydrocolloids have been used for a long time as a means of the stabilizing emulsions and foams. Glicksman (15) had shown that most of the hydrocolloids had at one time or another been used as ice cream stabilizers. They acted principally as surfactants (surface active agents), or wetting agents in the emulsion stabilization. Many workers (7, 8, 9, 15) demonstrated that they reduced the surface tension of the water phase and formed strong interfacial films (insoluble substances) which were not easily dispersed and thus formed a stable emulsion. The value of emulsifying agents was essential to improve whipping quality of ice cream mix, to produce a smoother body and texture, to lengthen shelf life of the products and provide more exact control in the various manufacturing processes. Another important ampplication of hydrocolloids was in the preparation of liquid flavor for use in baked goods, bottled beverages, confectionery and ice cream (5, 7, 15). Although a foodstuff may contain certain natural emulsifying constitutents, they produce only a small effect on the emulsifying stabilization; hence the addition of commercial emulsifiers are necessary to improve the quality of the products (7, 9).

V. STABILIZERS USED IN CREAMED COTTAGE CHEESE

Stabilizers in Creamed Cottage Cheese

In his two technical papers (34), Angevine demonstrated that an ideal cottage cheese should be one in which the basic flavor would be similar to fresh clean cultured milk or cream, should be mildly acid,

have a light salty taste and with flavor and aroma of good lactic butter culture. The body and texture of cottage cheese should be uniform, smooth, and meaty (not too firm or too soft and pasty). Cottage cheese should consist of uniform sized particles and have a natural color. Creamed cottage cheese should have a uniform layer of cream around the curd particles with a minimum of free cream. Any excess cream should be of thick consistency.

Milk and milk products contain natural stabilizing and emulsifying materials, but an additional stabilizer specially designed is needed and added in the cream to aid in the production of high quality cream cottage cheese. The stabilizers used in the cottage cheese are commonly a combination of hydrocolloids. The hydrocolloids which are ususally used in the cottage cheese are agar, alginates, carrageenans, furcellaran, guar or locust bean gum and sodium carboxymethylcellulose (15). Stabilizers can provide many advantages in the manufacture of creamed cottage cheese, such as keeping the creaming mixture and curd evenly distributed to provide a uniform filling operation, locking the creaming mixture onto the curd to prevent unsightly wheying off, to greatly extend the shelf life of the cheese, impart eye appealing gloss to the finished cheese, reduce the foam and enable the operation to meet weight standard, and lubricating the curd resulting in less breakage during the mixing and filling operation (25, 27, 30, 34).

Quantity of Stabilizers to be Used in the Dressing

The amount of stabilizer used in the cottage cheese dressing was governed by several factors. These factors were: (a) percentage of fat

in dressing, (b) size of curd to be creamed, (c) percent of total solids in dressing, (d) methods of creaming (in the vat or at the filler), (e) time between creaming and packaging, (f) types of packaging equipment, and (g) local preference for creaminess of cottage cheese (12, 26, 34).

The lower the fat content of the dressing, the more dressing required to obtain 4 percent fat in the finished creamed cottage cheese which is the legal standard in most states. In a small curd cheese, there is a large surface exposed and the dressing is absorbed rapidly to give a dry appearing finished cheese. Hence, a high level of stabilizer is needed to slow up this absorption. In the case of a large curd cheese, the exposed surface area is small and the absorption of dressing is slower than that in the small curd cheese; therefore, reduction in the amount of stabilizer is desirable in a dressing used for creaming large curd cheese (26, 34).

Many manufacturers have added serum solids (condensed skim milk or skim powder) to the dressing to increase viscosity for adherence to the curd. These solids can be eliminated or optionally reduced when stabilizers are used (26, 34).

When the curd was creamed directly at the filler, the time for absorbing the correct amount of dressing was short. Maintaining constant gentle agitation and a high level of stabilizer was necessary to insure uniform packaging. Where the curd was creamed in the vat the absorption of the correct amount of dressing was sufficient to allow handling properly at the filler. If there was local preference

to the creaminess of the finished creamed cottage cheese, this could be adjusted by varying the stabilizer level to control the amount of absorption or by the amount of cream dressing added to the curd (12, 34).

A level of 0.2-0.35 percent of stabilizer in a dressing has been found to give excellent results. Usually no more than 0.5 percent of any stabilizer is used because an excessive amount makes the products too viscous and imparts a sticky or gummy body (25, 26, 27, 30, 31, 32, 33). Since the stabilizers are highly concentrated, adjustments in the amount used should be made by increasing or decreasing the stabilizers by not more than 0.02 percent (14, 15, 25).

Factors to be Considered in Selecting a Stabilizer

The selection of the best stabilizers for any specific application, besides their required functional properties, included the physico-chemical characteristics of the stabilizers such as appearance, odor, color, mouthfeel, solubility, stability and legal considerations (15, 18). Glicksman (17) listed the following factors to be considered in selecting a stabilizer: (a) type of product application, (b) emulsifying properties, (c) use of stabilizer combinations, (d) compatibility, (e) preservation, (f) viscosity, and (g) cost.

VI. SUBJECTIVE EVALUATION OF FOOD FLAVOR

There has been an increasing effort to develop objective methods via chemical and physical tests to evaluate instrumentally the properties of food. However, flavor factors in particular were

difficult, if not impossible, to measure by any but the subjective human measurement such as taste panels or the profile method. Flavor elements existed in small quantities, such as parts per million or less, and might contain large numbers of chemical substances which were not perceived as separate substances (3, 19, 20). With the rapid development of new research techniques, gas chromatography along with mass spectrometer enabled flavor compounds to be measured. But these techniques just responded to a certain single flavor, not to total flavor. Although a vast number of individual substances were isolated on the gas chromatograph that might or might not have some relationship to flavor perception, the objective method could not indicate the mouth-feel or the flavor acceptability when the food was presented to consumers. In the evaluation of food flavor, an instrument could not replace the human senses, the evaluation relied upon the reactions of people rather than the reactions of instruments (2, 3, 20, 21). So, in the studies of flavor, many of the human flavor evaluation techniques which relied upon human sensory responses were designed to eliminate personal preference judgement (3, 4, 20).

A subjective evaluation was made by the senses of taste, smell, and touch when food was eaten. With the interaction of taste receptors and olfactory nerves, food quality in programs was evaluated for quality control and new product development. This evaluation was usually carried out by several persons (2, 21). Because of the nature of subjective judgement, the results between panels were influenced by human psychological factors. Statistical techniques were useful in

estimating the reliability of the panel's observation and avoided misleading by these human imperfections. Thus, the sensory panel conducted on a statistical basis could be said to be a psychophysical test based on psychometrics (20, 23). For the optimal performance of a sensory testing panel, all testing methods and conditions had to be rigidly controlled so that the results might be arrived at independently and overcome errors caused by psychological factors. "Error" was not synonymous with mistake, but might include all kinds of extraneous influences (4, 20, 21).

Candidates for sensory evaluation of food should be screened on the basis of their ability to differentiate relatively small differences of flavor and, perhaps more importantly, to be able to differentiate these differences consistently. Selection of panelists for laboratory type panels could well begin with the institutional personnel who may be interested in participating. No one should be asked to evaluate foods to which he objected (20, 23). The procedures used for sensory evaluation of materials, products, and foods can be used to screen candidates for sensory judgement panels. However, tests that were used to discriminate among candidates should have some featured difference from those used to discriminate among materials. There are three screening procedures to be used in the selection of panelists. They are triangle test, the intensity rating test, and the multicomponent odor identification test. Among these screening procedures, the triangle test is economically able to rapidly eliminate candidates who have difficulty with a test procedure (2, 3, 20). In order to be assured of

the ability of panelists to differentiate consistently, the screening test should be repeated at least three times. Generally the more tasters on the panel the more reliable the results and individual variations will be balanced. Four panelists is probably the minimum number. Most researchers suggested that the number of panelists should be eight or ten (4, 23).

There are two basic types of sensory panels, the difference sensory panel and the preference sensory panel. In the difference types, the members of the panel were asked to indicate if a difference existed between two or more products. The difference sensory panel was particularly useful in evaluating the effect of changes in processing procedures or in formulation. In the preference test, the members of panel were asked to score the products in an attempt to evaluate the desirability of a flavor change. With the total scores from trained panels, the results predicate the preference or acceptance of the total population. Both types of panels have certain advantages and disadvantages (21, 23).

The degree of precision from a difference test primarily depended upon the degree of training and the sensitivity of the panel members. The difference test required a relatively small number of tasters and the procedure was simple and inexpensive to conduct. However, the test had the disadvantage of providing no indication of whether or not the difference was desirable (19, 23). The common true difference tests are referred to as the triangle test, the duo-trio test, the paired comparison test, ranking, scoring and multiple comparison. The triangle test of selecting the odd sample was considered the most common for this

purpose, but there was sufficient evidence to indicate that a scoring or ranking system and a multiple comparison with statistical analysis was much more efficient (20, 21, 23).

The reliability of results from a preference test also depended to a certain extent upon the training and sensitivity of the panel members. The preference test could provide an indication of significant difference in preference or acceptance among the samples. However, the test required the use of many people on the panel and was very expensive and time consuming to conduct (23). The preference test included scoring, ranking and paired comparison. In general, paired comparison was a minimal case and was used as a foundation stone in the building of a rationale of preference test. Some form of a hedonic scale would be used with the paired comparison and was found very useful in determining preference (10, 17, 21).

The accuracy of subjective evaluation of food and the reliance that can be placed on their results depend on standardization of testing conditions and use of statistical methods of experimental design and analysis. The differences of opinion between panelists are so large that it is difficult to determine whether or not the results are meaningful. Statistical techniques are useful in estimating the reliability of the panel's observation. Preference scores are meaningless unless there is a statistically significant difference (20, 23).

CHAPTER III

MATERIALS AND METHODS

I. SOURCES OF STABILIZERS

Seven different stabilizers used in creamed cottage cheese were secured from manufacturers and were used to evaluate their usage in creamed cottage cheese. The companies which supplied the stabilizers were:

1. National Pectin Products Company, Chicago, Ill.
2. Stein Hall, New York, N.Y.
3. Germantown Manufacturing Company, Broomall, Penn.
4. Darimix Control Division, Rochester, Minn.
5. Stabilized Production Inc., Sappington Branch, St. Louis, Mo.

II. RAW MILK, CREAM AND DRY COTTAGE CHEESE

Raw mixed herd milk routinely supplied to the University Creamery and cream with 38 percent fat content separated by the University Creamery were used in this study. Dry cottage cheese was obtained from Pet Dairy Division, Knoxville, Tennessee. Raw milk and cream were pasteurized within 12 hours and stored at 7°C. Dry cottage cheese was stored at 7°C also, and creamed within 24 hours.

III. QUANTITY OF STABILIZERS FOR USE

The quantity of stabilizers used was that recommended by the manufacturers and depended upon kind of stabilizers and the fat content of dressing.

Stabilizer No. 1 with 12 percent butterfat in cream used 0.20 percent stabilizer (30).

Stabilizer No. 2 with 4 percent fat in cottage cheese used 0.3 percent stabilizer (31).

Stabilizer No. 3 with 4.0 percent fat in cottage cheese used 0.3 percent stabilizer (27).

Stabilizer No. 4 with 10 percent fat dressing used 0.3 percent stabilizer (25).

Stabilizer No. 5 with small curd cheese (1/4 inch knife) used 0.28 percent stabilizer, large curd cheese (1/2-1 inch knife) used 0.18 percent stabilizer (26).

Stabilizer No. 6 with 12 percent butter fat dressing used 0.3 percent stabilizer (32).

Stabilizer No. 7 with 10-12 percent butter fat dressing used 0.25 percent stabilizer (33).

Salt was added in the cream to taste, at 0.25 percent weight of dressing.

IV. PREPARING THE SAMPLES FOR TESTS

Each sample was made with only one stabilizer to be tested. For the triangle test a sample without stabilizer was made. The following

procedure was used for preparing samples: The cream (38 percent fat) separated by the University Creamery was mixed with the raw milk (4 percent fat) to make 12 percent fat cream dressing. The exact amount of stabilizer was weighed and premixed with salt in mortar and this mixture was dispersed into the cream dressing with maximum agitation by a stiff spatula. Then, the cream dressing with stabilizer was pasteurized at 74°C for 30 minutes. The pasteurizer was a Thermonitor Controlled Constant Temperature Bath made by E. H. Sargent and Company and the milk was placed in 1000 ml. Roux bottles for pasteurization. After pasteurization, the cream dressing was homogenized in a Virtis "45" Homogenizer for one minute with a setting of 55 (about 24,000 RPM). Following homogenization, the dressing was cooled and stored at 7°C for preparation of dressing for the cottage cheese.

V. VISCOSITY AND HOMOGENEITY

Viscosity

The cream dressing was warmed to room temperature for viscosity and homogeneity tests. A Brookfield Synchro-Lectric Viscometer, LV Model was used to measure the viscosity of the cream dressing. The No. 1 LV spindle was selected for this measurement. The revolution per minute of the spindle was selected at 60 RPM and the temperature of the samples was controlled at 25°C by using water bath. The methods as outlined by the manufacturer (6) were followed to measure the viscosity of the cream dressing.

Homogeneity

After homogenization, the cream dressing stood undisturbed for 48 hours at refrigerator temperature in Roux bottle at same level. The upper and the lower portion were then analyzed for fat content. Well homogenized cream should not have a difference to exceed 10 percent of itself fat content (16). The Babcock Method (1) was followed to analyze the fat content.

VI. DRESSING THE COTTAGE CHEESE

The curd was dressed at 4.4°C with the cream dressing to give a fat content of 4 percent in the cheese. Then the samples were presented to the sensory panel for triangle test or multiple comparison test.

VII. SENSORY PANELS

Triangle Test

Three samples of cottage cheese coded with random numbers were presented to the taste panel. Two of the samples which were identical either had a stabilizer in the dressing or a dressing without stabilizer. The odd sample was the opposite of the two identical samples. The panel members were asked to taste the three samples and indicate which sample was the odd one, and which was preferred the paired or the odd. Twenty one persons served as panelists in this test and the test was made for each of the seven stabilizers. The sensory panel consisted of 5 female and 16 male members between the ages of 21 and 53 years. Ten of the 21 panelists were staff members; 11 were graduate students of the

Department of Food Technology and Science. The tests were performed between 10:00 AM and 12:00 AM.

Multiple Comparison Test

A creamed cottage cheese from Pet Dairy Division, Knoxville was labeled "R" as a reference sample and presented to the taste panel with seven coded samples each consisting of one of the seven different stabilizers. Number 3 stabilizer was used in the reference sample. The panelists were asked to score samples in comparison to the reference sample. A hedonic rating system with a nine-point scale was used to score the coded samples. Ten panelists selected from the 21 panelists of the triangle test, were selected for this comparison. Three replications were conducted in this test.

VIII. STATISTICAL ANALYSIS

Statistical analysis of variance by variance ratio (F value) was applied as outlined by Larmond (21) and a 5 percent level significant was selected. In the analysis of the triangle test, the panelists were listed on the following basis; the panelists and their scores (number of correct answers) in order with highest score first, then listed in the order of the number of correct answers which they gave. As recommended by Wittes and Turk (3), confidence limits were set at about 25 or 30 percent, rather than the usual 5 percent. In this study, 21 panelists each performed seven triangle tests. A difference in score of 2 or more indicated a significant difference in performance. Then

starting from the top, the panelists that differed among themselves by less than 2 in score, were considered to be "equal" and were selected as panelists for the multiple comparison test.

The results of the triangle test were tested for statistical significant difference using the Merck Technical Bulletin (23). The point corresponding both to the number of judges and the number of correct decisions was located on the chart. If the point was below both curves there was no significance. If this point lay on or above the lower curve, but below the upper curve, the results were significant at the 5 percent level. If it fell on or above the upper curve, the results were significant at the 1 percent level.

In the Multiple Comparison, the analysis of variance was calculated as outlined by Larmond (21). If the variance ratio was not significant, the conclusion was that the addition of stabilizers did not make a detectable difference in the flavor of cottage cheese. If there was a significant difference between the samples, the ones that were different were determined by using Duncan's Multiple Range Test (11, 21) to compare sample means.

CHAPTER IV

RESULTS AND DISCUSSION

The evaluation of seven stabilizers has been carried out and an attempt to determine, if possible, which was most satisfactory to use as a cottage cheese dressing stabilizer. These laboratory examinations have been carefully made. The organoleptical test of the panel with reference to flavor was performed and the preference of these stabilizers was scored. The data were analyzed by statistical analysis of variance.

I. DEGREE OF HOMOGENIZATION

In homogenization of cream for the dressing, the number of fat globules and the surface-to-volume ratio of the globules is increased. The United States Public Health Service stated that in well homogenized milk the fat percentage of the upper portion does not differ by more than 10 percent of itself from the fat percentage of the lower portion after 48 hours storage (16). The data on the homogenization efficiency of the cream dressing with and without stabilizer is shown in Table I. The dressing without stabilizers exhibited poorer homogenization than the dressing with stabilizers. It seemed to be the fact that the stabilizers reduced the surface tension by binding the free water and thus increased the homogenizing efficiency. However, the fat percentage difference between upper and lower portions in the cream was more than 10 percent of the cream itself. In a well homogenized

TABLE I

THE DEGREE OF HOMOGENEITY OF CREAM DRESSING WITH DIFFERENT STABILIZERS

Source	Percent Difference of Fat Content Between Upper and Lower Portions							
		Stabilizers						
	Without Stabilizer	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Means[a]	6.91	4.18	4.18	3.43	2.73	3.70	2.75	2.03
Coefficient Variance	7.61	6.60	7.03	9.04	8.17	8.38	9.13	7.89

[a] Means of 4 observations.

cream, the difference should not be in excess of 1.2 percent, while in this study, the least difference (2.03) of the No. 7 stabilizer still exceeded this limit. The result indicated that the speed and time used for the "45" VirTis Homogenizer was not adequate for the homogenization of the cream. According to the technical operation manuals, the cream should be homogenized at 2,000 to 3,000 pounds per square inch (16, 26, 30). The shearing force in the "45" VirTis Homogenizer was apparently not enough to reach this requirement. The data in Table I also shows that the homogenization efficiency among the dressings with stabilizers varied widely. However, the effect of homogenization efficiency with the stabilizers on the creamed cottage cheese was not the important factor to be considered by dairy plants in the selection of stabilizers because adequate homogenization was easily performed in most dairy plants.

II. VISCOSITY

Viscosity was determined by measuring the resistance to flow by using the Brookfield Viscometer. Viscosity was expressed in centipoise. After pasteurization and homogenization, all samples were tempered at 25°C and measured. The data in Table II show that all the cream dressing with stabilizers demonstrated higher viscosity than the dressing without stabilizers. From the results, the conclusion may be drawn that the stabilizers remarkably increased the viscosity of the cottage cheese dressing. This occurred because the stabilizer exercised a profound effect on the water binding capacity. The viscosity of the

TABLE II

THE VISCOSITY OF CREAM DRESSING WITH DIFFERENT STABILIZERS

Source	Brookfield Apparent Viscosity in Centipoise at 25°C							
	Without Stabilizer	Stabilizers						
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Means[a]	5.00	21.67	16.16	83.03	55.30	27.53	56.06	26.87
Coefficient Variance (%)	5.28	7.11	7.79	4.34	5.01	5.83	4.81	5.80

[a]Means of 3 observations.

TABLE III

THE PANELISTS IN THE ORDER OF NUMBER OF CORRECT ANSWERS AND TESTS

Panelists	Number of Tests	Number of Correct Answers
A	7	7
B, C	7	6
D, G	7	5
E	7	3
F, H	6	5
I, J	4	3
L, M, N	4	2
S, U	4	1
K	3	3
P	3	2
Q	3	1
O	2	2
R, T	2	1
Total 21	97	66

times or less in this test were not considered for the panel, except panelist K who had three correct answers of three tests.

For a rough screening operation, a 0.2 to 0.3 significant level (70 to 80 percent confidence level) was accepted (3). In this study, the number of tests by each panelist was four or more. A difference in the number of correct answers of 2 or more indicated a significant difference in performance. In Table III, A, B, C, D and G differed among themselves by not more than 2 in the number of correct answers. This difference was not significant and therefore they were considered to be "equal" (3). In the case of F, H and I, J, while their tests were 4 or 6, the difference in number of correct answers was less than 2 so they also were considered to be "equal". Since ten panelists were needed in this study, panelist K with three correct answers of three tests was selected instead of L, M, or N. Therefore, the panelists in this study included A, B, C, D, F, G, H, I, J, and K.

Data from the triangle test was used to compare the 7 stabilizers to cottage cheese creamed with a dressing with no stabilizer added. This evaluation was desired to arrive at an opinion as to the degree to which the stabilizers would meet the demands of the public. The triangle test was used to evaluate the difference of the stabilizers. With 21 panelists using the triangle test a significant difference occurred in the cottage cheese with six of the seven stabilizers used in the cheese dressing (Table IV). With stabilizer No. 2 there was no significant difference in the cottage cheese on which it was used. However, among 97 tests, 66 correct decisions were made by the panelists,

TABLE IV

TRIANGLE TESTS OF SEVEN STABILIZERS

Source	Total	Stabilizers						
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
No. of Tests	97	14	15	14	13	14	13	14
No. of Correct Answers of Panelists	66**	10**	7	9*	9*	10**	10**	11***
No. of Preference to the Samples With Stabilizers	56**	10**	6	8*	6	9*	8	9

*5 percent level of significance.

**1 percent level of significance.

***0.1 percent level of significance.

which indicated there was a significant difference between the samples with the stabilizers and the samples without the stabilizers. This difference was significant at the 1 percent level of significance.

IV. MULTIPLE COMPARISON TEST

The data in Table IV also show the preferences of the panelists to the samples with stabilizers. In the case of No. 2, No. 4, No. 6, and No. 7 stabilizers, there was no statistical significant preference to the samples with these four stabilizers added. Since 56 preferences were made by the panelists to the 66 samples with stabilizers, summarily there was a significant preference for the cottage cheese with stabilizers at the 0.1 percent significant level. Although the difference test indicated a preference to the samples with stabilizers, it provided no indication of the degree of this preference among the stabilizers.

A multiple comparison test was conducted to evaluate this preference among these seven stabilizers. The data of this study are shown in Table V. Ten panelists, selected from the triangle test panel, were asked to evaluate these samples according to a score sheet (Appendix A). The three replications were completed by seven of the panelists and two replications only by three of the panelists. So the total comparison tests conducted in this study was 27. The ratings were given numerical values of 1 to 9 by the panelists analyzing the results with "no difference" equalling 5, "extremely better than R" equalling 9, and "extremely inferior to R" equalling 1. The analysis of variance was calculated and is shown in Table VI. Since the calculated F value

TABLE V

MULTIPLE COMPARISON TEST OF SEVEN STABILIZERS

Panelists	Replications	Score* of Creamed Cottage Cheese with Seven Stabilizers							
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	Total
P_1	3	7	6	6	5	3	2	2	31
		5	7	2	2	7	5	1	29
		2	6	6	2	6	5	1	28
P_2	3	6	5	6	4	6	7	3	37
		8	8	6	6	8	5	4	45
		8	6	8	7	8	6	6	49
P_3	3	7	5	6	6	6	5	6	41
		5	6	5	5	5	5	2	33
		4	4	5	6	4	4	2	29
P_4	3	5	4	6	3	7	6	6	37
		7	7	6	2	6	6	7	41
		7	7	5	4	6	5	7	41
P_5	3	6	7	5	6	7	5	4	40
		4	5	3	6	5	7	3	33
		5	4	4	6	3	6	2	30
P_6	3	7	2	3	8	4	4	4	32
		2	5	6	7	8	9	4	41
		5	6	6	4	5	2	4	32
P_7	3	5	4	4	5	4	8	2	32
		7	5	7	4	3	7	7	40
		5	5	7	6	5	5	4	37

TABLE V (continued)

Panelists	Replications	Score* of Creamed Cottage Cheese with Seven Stabilizers							
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	Total
P_8	2	7	5	6	6	4	5	3	36
		6	5	7	2	5	6	7	38
P_9	2	4	5	4	4	4	3	2	26
		6	5	7	6	6	6	2	38
P_{10}	2	3	3	3	3	5	6	3	26
		3	4	5	5	4	4	4	29
Total 10	27	146	141	144	130	144	144	102	951

*The scores were given numerical value 1 to 9:

1. Extremely inferior to R.
2. Much inferior to R.
3. Moderate inferior to R.
4. Slight inferior to R.
5. No difference with R.
6. Slight better than R.
7. Moderate better than R.
8. Much better than R.
9. Extremely better than R.

TABLE VI

THE ANALYSIS OF VARIANCE OF MULTIPLE COMPARISON TEST

Source of Variance	DF	SS	MS	F-ratio
Samples	6	55.88	9.31	4.23**
Panelists	26	130.67	5.03	2.29**
Error	156	343.26	2.20	
Total	188	529.81		

**1 percent level significance.

(4.23) exceeded the variance ratio (2.96) as checked in statistical chart (21), there was a significant difference at 1 percent level between the stabilizers. This provided evidence that the addition of stabilizers to the creamed cottage cheese made a detectable difference in the flavor of the cottage cheese.

The means that were different among the samples were determined by using Duncan's Multiple Range Test (11). The sample means were calculated and compared with the "shortest significant range" at the 5 percent level. The calculation and comparison are shown in Table VII. The standard notation was the following:

A(No. 1), B(No. 3), C(No. 5), D(No. 6), E(No. 2), F(No. 4), G(No. 7)

Therefore, the conclsuion was made that G was different from the others at the 5 percent level. In other words, No. 7 stabilizer was significantly inferior to the other six stabilizers. In the selection of the stabilizer to use in the creamed cottage cheese, the other six stabilizers could be considered to be "equal", since there was not a significant difference among them.

Stabilizer No. 7 was inferior to the other six stabilizers mostly in the effect on the flavor. Some panelists commented that the flavor of the samples with this stabilizer was oxidized or rancid. The hedonic score of the No. 4 stabilizer was low enough not to receive consideration for use in cottage cheese although it was not statistically inferior to the reference sample. Some comments which were made on the sample with

TABLE VII

COMPARISON OF PANEL SCORE BY DUNCAN'S MULTIPLE RANGE TEST

Source	Stabilizers						
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Sample score	146	141	144	130	144	144	102
Sample means	5.41	5.22	5.33	4.81	5.33	5.33	3.78

* * * * * *

The sample means are arranged according to magnitude:

A	5.41						
B			5.333				
C					5.33		
D						5.33	
E		5.22					
F				4.81			
G							3.78

* * * * * *

The standard error of the sample mean: 0.285

* * * * * *

The shortest significant range RP:

P	2	3	4	5	6	7
P(5%)	2.77	2.92	3.02	3.09	3.15	3.19
Rp	0.7895	0.8322	0.8607	0.8807	0.8978	0.9092

Comparison with the shortest significant range RP:

A-G = 5.41 - 3.78 = 1.63 > 0.9092 (R_7)

A-F = 5.41 - 4.81 = 0.60 < 0.8978 (R_6)

* * * * * *

The standard notation was: A B C D E F G

this stabilizer concerned the effect on the texture such as lumpy, mealy, flat, and cardboard taste.

Data in Table V (pages 33,34) demonstrated that there was a difference between panelists in response to the samples. Some panelists were more critical of the samples as shown by lower hedonic scores and some panelists made the judgements within a narrow range score. This could be because the taste panel results were influenced by human psychological factors and those human preference to the samples. The data in Table V also indicated the widely different score given to the same sample by the same panelist. The factors to be considered in this situation were mostly the physical and mental condition of the panelist. For example, one panelist may have more flavor acuity in the morning, others in the afternoon or the panelist smoked within one or two hours before the taste.

The statistical treatment of this taste panel data indicated there was a difference between the samples, but it does not provide the evidence of how closely these results would compare with the reactions of the public. So, the result should also be interpreted with common sense.

In the present study, the evaluation of stabilizers was conducted by a competent sensory panel. However, some instrumental analyses were needed to correlate with the sensory evaluation. Gas-liquid chromatography and spectrometry may be used for the measurement of flavor quality. Texturemeter and tenderometer (20) can be used to measure the texture such as chewiness and firmness. Thus, the correlation of

instrumental analysis and sensory evaluation might help to evaluate its importance in consumer quality evaluation of a food.

This study provided the methods which could be used in a dairy plant to evaluate the stabilizers for most satisfactory use in the manufacture of creamed cottage cheese. The panelists can be selected from staffs, secretaries, salesmen and consumers by triangle test and the evaluation can be performed by multiple comparison test.

CHAPTER V

SUMMARY AND CONCLUSIONS

Seven different stabilizers secured from 5 companies were used in the creamed cottage cheese. Homogeneity and viscosity of dressings were analyzed to evaluate the effect of the stabilizers on the cottage cheese. The creamed cottage cheese was evaluated by a taste panel using a multiple comparison test with a hedonic scale.

From the data from subjective and objective tests, the general conclusions in this study may be summarized in the following statements:

1. Although difficulty of homogenization was encountered by using the VirTis "45" Homogenizer, homogeniety of cottage cheese dressing was improved by the addition of stabilizers. The degree of homogenization varied among the different stabilizers.

2. On the basis of viscosity, the stabilizer served to increase the viscosity of the cottage cheese dressing. The viscosity also varied widely among the different stabilizers which were used, in some cases, at the same percentage.

3. The data obtained from the sensory test group showed that the acceptance of creamed cottage cheese with stabilizer in the dressing was preferred to the creamed cottage cheese without the stabilizer in the dressing.

4. There was a significant difference among the seven stabilizers in the effect on the flavor of the creamed cottage cheese. A

significant difference in preference of stabilizer No. 7 from the other six stabilizers was noted which showed it to be inferior to the reference sample. The other six stabilizers were considered to be equal for use in the creamed cottage cheese.

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APPENDIX

APPENDIX A

MULTIPLE COMPARISON SHEET

Name _____ Date _____

You are receiving seven different kinds of samples to compare to a reference sample marked R. Please taste each sample; show whether it is better than, comparable to, or inferior to the reference. Then mark the amount of difference that exists.

Sample number	____	____	____	____	____	____	____
Better than R	____	____	____	____	____	____	____
Equal to R	____	____	____	____	____	____	____
Inferior to R	____	____	____	____	____	____	____

Amount of Difference

None	____	____	____	____	____	____	____
Slight	____	____	____	____	____	____	____
Moderate	____	____	____	____	____	____	____
Much	____	____	____	____	____	____	____
Extreme	____	____	____	____	____	____	____

Comments:

VITA

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