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To the Committee on Graduate Study:

I am submitting to you a thesis written by Herman N. Carringer entitled "The Use of Stabilizers in Ice Cream." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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THE USE OF STABILIZERS IN ICE CREAM

A THESIS

Submitted to
The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Herman N. Carringer

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Herman N. Carringer

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CHAPTER I

INTRODUCTION

A stabilizer is one of the supporting solids used in ice cream mix. Gelatin is one of the common stabilizers used in ice cream. It serves, as do the other stabilizers from animal or vegetable origin, to prevent the growth or development of large ice crystals which will cause a coarse texture in the finished product. The amount to use depends upon such factors as fat content, total solids content, viscosity desired, pressure of homogenization, condition of pressure valves on homogenizers, acidity, and strength of the stabilizer used.

Many stabilizers were introduced during the war because of the shortage of gelatin and sodium alginate. Most of the new stabilizers are sold under trade names, but are from animal or vegetable origin. They are usually mixtures of various gums, sea weeds, and gelatin with cane sugar, dextrin, whey powder, and sodium citrate as diluents or carriers and may contain a whipping aid or an emulsifier.

This study was undertaken for the purpose of comparing the efficiency and characteristics of various stabilizers used in ice cream mix with a basic stabilizer, sodium alginate (or Dariloid), as the index to the study.

The importance of the study is quite obvious if we consider the growth of the ice cream industry in the state of Tennessee. Before the war years, the average consumption of ice cream in Tennessee was approximately nine million gallons annually. In 1947, the consumption in Tennessee reached an all time record of approximately sixteen million gallons, and the 1948 report is expected to exceed the previous year's record. The ice cream industry has many problems in producing, storing and delivering to the general public a good flavored ice cream with a smooth body and texture. If ice cream were consumed immediately after it is produced, there would not be any problem of stabilization, because the development or growth of ice crystals would be small and there would be no severe criticism from the consuming public on the body and texture.

Since ice cream is stored several days before it is consumed by the public, it is necessary to use some type of stabilizer in the ice cream mix to provide and maintain a good smooth texture in the finished product.

CHAPTER II

REVIEW OF RELATED LITERATURE

History of Ice Cream Stabilization

Alberts (1) reports the need for some type of mix stabilizer to improve the texture and body of ice cream was recognized as far back as the eighteenth century, for ice cream recipes of that period mentioned the use of arrowroot flour in conjunction with cream, sugar, and eggs. Many home recipes of today include stabilizers for the same reason. Alberts (1) also reports that gelatin as a stabilizer in ice cream was discussed as early as 1905. Since that time various other products have been developed which are now commonly used for improving the body of ice cream; among them might be mentioned sodium alginate (Dariloid) and stabilizers containing Irish moss, pectin, carob bean derivative, and certain gums.

Factors to Consider in the Selection of a Stabilizer

Stabilizers function through their ability to form gel structures in water solutions or their ability to combine with water as water of hydration. Turnbow and Tracy (29) state that the importance of stabilizers in ice cream is dependent, to a certain extent at least, upon the percentage of water in the frozen product which needs

to be stabilized and upon the conditions under which the product is to be held after being frozen, that is, length of time and temperature of storage. Tracy and Turnbow (29) report that not all the water in ice cream is frozen and as the temperature is lowered below the initial freezing point of the mix, ice cream crystals form, and the freezing point of remaining portion is lowered because of the increased concentration of soluble constituents (sugars and salts). This process continues until the minimum temperature of storage has been reached, at which point possibly 90 percent of the water is frozen. If the temperature of storage fluctuates, there will be a certain amount of melting and re-freezing which would result in the formation of large ice crystals were it not for the presence of a stabilizer. In selecting the stabilizer for the ice cream mix, Turnbow, Tracy and Raffetto (29) state the following factors should be considered:

1. Ease of incorporation
2. Food value and sanitary qualities
3. Effect upon mix viscosity
4. Effect upon whipping
5. Ability of stabilizer to retard ice crystals
6. Type of body produced in ice cream
7. Melt-down characteristics of ice cream
8. Flavor of ice cream
9. Quantity necessary to produce desired stabilization
10. Cost

The Requirements of an Ice Cream Stabilizer

The purpose or function of stabilizers in the ice cream industry as previously stated is to maintain a smooth body and texture in the ice cream or to prevent the appearance of large ice crystals.

Dahle and Collins (8) list certain requirements for ice cream stabilizers other than texture requirements as follows:

1. Must be non-toxic and safe to use
2. Must meet state requirements as to maximum amount used (usually 0.2 to 0.5 percent of mix)
3. Must be readily dispersed in the mix
4. Must not clog strainer or filter
5. Must not cause separation of mix
6. Must provide good melt-down of ice cream
7. Must not cause excessive viscosity when used in proper amounts
8. Must not cause excessive foam in the mix
9. Must maintain strength on standing

The Amount of Stabilizer to Use in Ice Cream

The amount of stabilizer to use in ice cream must be worked out in the ice cream plant. Dahle (8) states that the exact amount will depend upon these conditions:

1. Strength and type of stabilizer
2. Composition of the mix (fat and solids)
3. Texture desired
4. Freezing and hardening conditions
5. Acidity of the mix

6. Homogenization (temperature, type of valve, single stage or dual pressure)
7. Heat shocking

The aim of the ice cream maker is to have all the above conditions under control and then add enough stabilizer to make an ice cream that will be free from noticeable ice crystals and with a good smooth body and texture. The amount to use should not and will not vary from day to day under normal conditions and the amount will be from 0.08 percent to 0.5 percent.

Gelatin as a Stabilizer in Ice Cream

Gelatin is one of the by-products of the packing industry and is produced in this country under strict government regulations. Tracy and McCown (32) report that in the vertebrates the protein material of the bones and the connective tissue is a mixture of several proteins, the most important of which is collagen. When collagen is heated in water, it is converted into gelatin. The change of the collagen into gelatin proceeds rapidly at high temperatures, particularly in the presence of a slight amount of acid. When the housewife makes soup with meat she converts part of the connective tissue into gelatin. The housewife has learned that a tough piece of meat can be made edible by adding vinegar before cooking,

which aids in converting the supporting framework into gelatin. What is done by the housewife in this simple manner is carried out by the gelatin manufacturer on a larger scale under technical control and supervision.

Measuring the Gel Strength of Gelatin

Turnbow, Tracy and Raffetto (29) report that since the gel strength is related to its ability to function in the mix, it is important to have some means of determining this value. Various tests have been developed, but the one that has been accepted by the Edible Gelatin Association is the bloom gelometer named for its inventor. It has become a trade practice to speak of the different bloom tests, as a 175 bloom or a 250 bloom gelatin. What is meant is a gelatin that requires a weight of 175 or 250 grams to make a certain depression in a solidified solution of the gelatin in water under certain standard conditions. The higher the bloom test, the higher the gel strength of the gelatin, therefore the smaller the amount that will be needed in the ice cream. The grades of gelatin used in ice cream vary from 150 to 300 bloom.

For determining the proper amount of gelatin to be used in a mix Dahlberg, Carpenter, and Hening (10) have devised a method which involves a determination of the amount of the unknown gelatin necessary to form a slight

gel in skimmilk. In this test quantities of a 10 percent gelatin solution are added to skimmilk in even proportions, so as to give a percentage range of gelatin in the mixture such as 0.2 percent to 0.5 percent. The mixtures are poured into test tubes, which are immersed in ice water for eighteen to twenty hours. The tubes are then inverted, and the concentration of gelatin, which is just sufficient to produce a gel of such firmness that it does not break away from the test tube, is considered to be the percentage desired.

Gelatin in Relation to Mix Viscosity

Leighton and Williams (20) observed that there are two types of viscosity in an aged ice cream mix. One type, the apparent viscosity, is the livery condition of the ice cream mix which, upon agitation, breaks down into the other type, or basic viscosity which, when once obtained, cannot be further reduced by agitation. The viscosity produced by gelatin in an ice cream mix is in a general way an index of the efficiency of the gelatin as a stabilizer of the ice cream. Gel formation occurs during aging, that period after processing and before freezing, during which the mix is stored at a temperature usually not higher than 40 degrees F. The aging period varies but usually is not

less than four hours nor longer than forty-eight hours. The gel formation occurs rapidly during the first few hours, after twenty-four hours the change is more gradual, and after forty-eight hours no appreciable change takes place. Carpenter and Dahlberg (5) found that weak solutions of gelatin required two weeks for gel to take place. Leighton and Williams (20) noted that, although the apparent viscosity was greater, the basic viscosity of a mix was the same after aging a week at 41 degrees F. as it was after aging twenty-four hours at this temperature. However, it is this apparent variation in viscosity which often confuses the freezer operator when he is supplied with mix aged for different periods of time.

The Relation of pH, Bloom Strength and Amount of Gelatin on Characteristics of the Mix

It was formerly thought that the pH of gelatin was of extreme importance in ice cream. Dahle and Collins (7) reported that pH does not matter greatly so far as ice cream results are concerned. Gelatin is sold according to bloom strength and so far gelatin is the only basic stabilizer sold to the ultimate user according to any test.

TABLE I

THE AMOUNT OF GELATIN OF VARIOUS pH AND BLOOM STRENGTHS TO GIVE A PERFECT BODY AND TEXTURE SCORE* #

Percent Gelatin Used	pH of Gelatin	Bloom Strength	24 Hour Viscosity of Mix (c. p.)	Time to Freeze and Whip	Texture Score 24 Hrs.	Texture Score 14 Days
0.5	4.4	150	141.1	5'03"	30.0	29.75
0.5	6.2	150	73.9	4'49"	30.0	29.75
0.42	4.4	200	97.4	5'21"	30.0	29.75
0.42	6.2	200	127.7	5'03"	30.0	29.75
0.35	4.25	250	60.5	4'32"	30.0	29.75
0.35	6.07	250	80.5	5'12"	30.0	29.75

*Dahle and Collins (7)

#In each case 90 percent over-run was obtained

Merits of Gelatin as a Stabilizer

The peculiar property which gelatin has of absorbing water and forming a gel when the temperature and concentration factors are favorable enables it to retard the formation of large ice crystals in the frozen ice cream. Dahlberg (11) reports the real value of gelatin in ice cream is due to the formation of a gel during the freezing process or immediately thereafter in the hardening room, which on account of its stiffness and internal structure prevents the growth of large ice crystals that cause coarse ice cream.

Gelatin also gives ice cream a certain amount of resistance, which aids in keeping it in a firm state when the temperature rises. Turnbow, Tracy and Raffetto (29) report that gelatin is easily incorporated into the mix without lumping if it is added before the mix rises above 110 degrees F.

Martin and Caulfield (23) report as the amount of gelatin added to the mix is increased the whipping period is extended. Unless the mix is overstabilized, the melt-down characteristics of the ice cream will be desirable. The edible gelatins manufactured today have no detrimental effect upon either the flavor or the color of the ice cream.

Dahlberg and Carpenter (10) report that the amount of gelatin used is seldom over 0.5 percent and is usually less, and it adds some food value to the ice cream. It is an incomplete protein, as it lacks the three amino acids: cystine, tyrosine, and troptophane.

Dahle and Collins (7) report the following as to the merits of gelatin as an ice cream stabilizer. Gelatin disperses readily in the mix without any trouble nor danger of lumpiness. It disperses better if mixed with sugar but most gelatin can be added without sugar. Gelatin is usually added to the mix before pasteurization temperature is reached.

Gelatin causes no separation of the mix nor any objectionable foaming during the manufacture and the mix

cools readily over the cooler. Gelatin mixes may show a high viscosity after storage of twelve or twenty-four hours. This occurs if high acid milk products, or excessive single stage pressure on the homogenizers, are used. The viscosity of gelatin mixes can be readily controlled if the mix is processed properly.

Stabilizers of Vegetable Origin

For a number of years there has been considerable interest in ice cream stabilizers of plant or vegetable origin. Their acceptance has been so widespread that probably over half the ice cream made in this country contains stabilizers of this type. Turnbow, Tracy and Raffetto (29) report that these products are for the most part hemicelluloses, and because of their hydrophilic properties they may be classed as gums. Gums have a fairly widespread distribution in the plant kingdom, being present in the leaves, roots, seeds, or stems of plants growing both on land and in water. Sodium alginate, agar-agar, and Irish moss are derived from sea weed, whereas gum tragacanth, Karoga gum, oat gum, and quince seeds are obtained from plants growing on land. Dahle and Collins (7) report that gums have a high affinity for water, which accounts for their effect upon mix viscosity.

In contrast to gelatin these products usually produce an immediate increase in mix viscosity, which changes but little with aging, so that their use has been particularly favored by those manufacturing mixes for resale. Turnbow (29) reports that gums vary in their action in the mix. Some are easy to disperse, but others, such as Karoga gum, are difficult to mix properly. Some of the gums react with the mix proteins, causing whey separation. Locust bean gum has this effect. Some gums, such as oat gum, have antioxidant properties. Certain gums impart peculiar flavors to the ice cream, and sometimes poor sediment discs can be attributed to the use of gum stabilizers. Gums have been used extensively in the manufacture of ices and sherbets, in which their water binding properties are particularly useful in producing a smooth texture and proper viscosity of the unfrozen mass. Because of the different characteristics of the gums, two or more are sometimes blended for use in ice cream. Gums have been combined with other products also, such as gelatins. Some of the commercial stabilizers on the market are examples of such mixtures.

Sodium Alginate as a Stabilizer in Ice Cream

Sodium alginate is an edible carbohydrate found in the giant Pacific coast sea weed, kelp. Mack (21)

reports in his publication on "Sodium Alginate as an Ice Cream Stabilizer" that this marine plant occurs in large beds, growing close to shore on rocky bottoms in ocean water from six to ten fathoms deep. The kelp grows from a holdfast attached to the ocean bottom and has been reported in lengths up to 1,000 feet but generally is 100 to 200 feet long. Since the plant is a perennial and grows rapidly, the beds may be harvested approximately three times a year without exhausting them.

Turnbow, Tracy and Raffetto (29) report that kelp is harvested by cutting off the plant four feet below the surface of the water. Upon arrival at the processing plant, the kelp is cut into fine pieces, after which it is thoroughly washed with hot water and digested with a controlled quantity of sodium carbonate to convert the alginate into a water soluble form. This treatment results in the formation of the soluble algin of commerce, sodium alginate. The digested mixture, which consists primarily of algin solutions and the suspended plant cellulose, is diluted and filtered to remove the cellulose completely. The algin is then treated with a dilute calcium chloride solution, which results in the precipitation of insoluble calcium alginate. Further washing and a treatment with hydrochloric acid removes the insoluble calcium compounds, thus leaving a material of alginic acid containing about 85 percent

water. Sugar and dextrin are added to standardize the colloidal efficiency, increase the solubility, and prevent caking of the final product. After thorough incorporation the mixture is dehydrated to 10 percent moisture in a drier, in which it is exposed to air of low temperature in order to preserve the natural colloidal properties of the algin. The dried product, Dariloid, is then ground, screened, and blended to uniform strength, after which it is packed in moisture-proof containers.

The use of sodium alginate in ice cream has been studied extensively by Sommer (26), Mack (21), Tracy and Tuckey (31), and by Dahle and Collins (7). It is somewhat difficult to correlate the results of these investigators because of differences in the strength of stabilizers and types of freezers used; in general they show sodium alginate to have considerable merit as a stabilizer for ice cream.

Sommer (26) reports that under ideal freezing conditions and with low gelatin content there was little choice between the two stabilizers in regard to whipping, but under reverse conditions the sodium alginates showed better whipping ability. Mack (21) found that sodium alginate was more effective than gelatin of average strength in improving texture and produced a faster whipping mix. Anderson and Hemboldt (2) reported that sodium alginate enhanced the

whipping ability of the mix and produced ice cream with a smoother, creamier melt-down. They recommended using 0.3 percent sodium alginate. Tracy and Tuckey (31) in comparing gelatin and sodium alginate, worked with mixes of different fat content, used both cream and butter as the source of fat, and employed different methods of processing and different types of commercial freezers. As a result of their study these investigators concluded that sodium alginate, because of its chemical affinity for calcium, produces an immediate increase in viscosity. This fact makes it important to avoid using an excessive amount of the stabilizer in order not to delay mix cooling and pumping operations. The pH was raised and the titratable acidity was reduced slightly by the sodium alginate. Comparable freezing results and body scores were obtained on commercial batch freezers when 0.3 percent Dariloid and 0.35 percent of a 225 bloom gelatin were used.

Mack (21) conducted some experiments comparing sodium alginate and gelatin as stabilizers in ice cream made in a batch freezer, the results of which appear in Table I. The gelatin used in this and other trials was a high grade product with a bloom gelometer test of 275. The usual commercial procedure of cooling mixtures below 50 degrees F. immediately after pasteurizing and homogenizing was followed in the study.

TABLE II

*
COMPARISON OF SODIUM ALGINATE AND GELATIN

Kind of Stabilizer	Percent Amount	Vis- cosity Sec.	Time to Reach 100% Overrun Min.	Body Criti- cisms	Texture Criti- cisms	Sedi- ment Score	Melting Appear- ances
Gelatin	0.35	32	7.2	Slightly Crumby	Smooth	9.3	Smooth Creamy
Sodium Alginate	0.35	27	6.5	Slightly Soggy	Smooth	9.1	Smooth Creamy
Sodium Alginate	0.3	24.2	6.2	Satis- factory	Smooth	9.2	Smooth Creamy
Sodium Alginate	0.25	20	6.0	Slightly Weak	Slightly Coarse	9.2	Melts Freely

* Mack (21)

Effect of Age on Sodium Alginate Mix

Mack (21) reports that one of the chief advantages of sodium alginate as a stabilizer is that aging the mix is not necessary. As soon as the product is brought into colloidal solution, hydration of the water of the mix already has occurred. Hence, as the mix leaves the cooler the viscosity has been attained and freezing of the ice cream mix may be done immediately. Prompt freezing of the ice cream mix is advantageous from the standpoint of economy as well as sanitation. Aging the mix requires more equipment, vat and floor space, and refrigeration. If ice cream manufacture is made a continuous process, which is possible by elimination of the aging period, greater efficiency of manufacture should be attained. Dahle and Collins (7) report that from the sanitary standpoint, the aging period increases the possibility of bacteriological contamination as well as bacterial increase. Mack (21) reports that the chief disadvantage of sodium alginate is that precautions are necessary in order to secure satisfactory solution. First of all, a temperature of 160 degrees F. must be reached before adding the stabilizer to the mix. At lower temperatures the product will form in sticky, rather insoluble lumps. The preparation of a

separate solution is likewise unsatisfactory because the sodium alginate produces viscosity immediately upon solution, and therefore too large a separate solution is required to insure proper dispersion. Dahle and Collins (7) report that sodium alginate may be added to the mix by adding with sugar of the batch and sifting slowly the sugar-stabilizer mixture evenly over the surface of the hot mix 160 to 165 degrees F. with the agitator running. This will insure satisfactory solution if sufficient agitation is employed. However, in vats where the agitation is not very thorough, some undissolved lumps may appear unless the sugar and stabilizer mixture is added rather slowly.

Martin and Caulfield (23) report a method of adding sodium alginate to the mix by merely pouring the stabilizer into cold water, stirring vigorously so as to wet the individual particles and promptly pouring the water-stabilized mixture evenly through the hot 160 to 165 degrees F. mix. This should not be done until the mix is hot, so that the cold water-stabilizer mixture can be added promptly. If the mixture is allowed to stand, the stabilizer will begin to swell and will become lumpy, hence more difficult to dissolve. This method has been found to be both simple and effective.

Mack (21) reports that the amount of sediment found in a sodium alginate mix depends entirely upon the

thoroughness of dissolving the stabilizer. If the stabilizer is properly incorporated into the mix, virtually no sediment appears from this source.

Josephson and Dahle (17) report that sodium alginate should prove especially satisfactory in mix made for resale; since the viscosity of mixes containing this stabilizer is attained immediately upon processing and cooling, the product requires no aging before shipment. The viscosity remains nearly constant regardless of the age of the mix and is less affected by temperature change than gelatin mixes. Perhaps no physical property of the mix is watched more carefully by the average buyer of mix than the viscosity. Hence, a reasonably constant viscosity is an asset with this type of business. Furthermore, a quick whipping mix is essential for resale because the purchaser of mix invariably uses batch freezers.

Merits of Sodium Alginate as a Stabilizer

Stebnitz and Sommer (27) reported from their investigations with sodium alginate and gelatin that, under ideal freezing conditions and with a low gelatin content, there was little choice between the two stabilizers in regard to whipping, but under reverse conditions the sodium alginate mixes showed better whipping ability. Mack (21) found

that sodium alginate was more effective than gelatin of average strength in improving texture and produced a faster whipping mix. Anderson and Hemboldt (2) reported that sodium alginate enhanced the whipping ability of the mix and produced ice cream with a smoother, creamier melt-down. Tracy and Tuckey (31) in comparing gelatin and sodium alginate worked with mixes of different fat content, used both cream and butter as the source of fat, and employed different methods of processing and different types of commercial freezers. As a result of their study, these investigators concluded that sodium alginate, because of its chemical affinity for calcium, produces an immediate increase in viscosity. This fact makes it important to avoid using an excessive amount of the stabilizer in order not to delay mix-cooling and pumping operations. The pH was raised and the titratable acidity was reduced slightly by the sodium alginate. Comparable freezing results and body scores were obtained on commercial batch freezers when 0.3 percent Dariloid and 0.35 percent of a 225 bloom gelatin were used. When frozen in counter freezers, the sodium alginate mixes whipped faster. The sodium alginate produced a drier body and a smoother, more rapid melt-down at room temperature. Neither the gelatin nor the sodium alginate used was found to contribute any flavor to the ice cream.

Hetrick and Erb (15) have studied the factors affecting viscosity formation in mixes containing sodium alginate. Disodium phosphate and sodium citrate, when added to the mix before the addition of the sodium alginate, caused an increase in viscosity. In the range from pH 6.2 to 7.2 an increase in acidity caused a decrease in viscosity. Raising the pasteurizing temperature from 160 to 180 degrees F. resulted in increased viscosity, and the longer the mix was held at 160 degrees F., the greater the viscosity. Slow cooling of the mix caused a marked increase in viscosity, as much as with gelatin mixes.

The study of Hetrick and Erb (15) is of particular interest because of the importance of proper viscosity control, especially when mixes are being manufactured for counter-freezer use. The operator of these freezers is confused by variations in mix viscosity from day to day. This change increase in viscosity which takes place after the mix is cooled is one reason why gelatin has not proved entirely satisfactory as a stabilizer for mixes of this type. Sodium alginate mixes, however, show practically no change in viscosity after cooling has once been completed; therefore, by proper control of processing methods the freezer operator can be supplied with mixes uniform in viscosity.

Mack (21) reports that a mix containing 0.3 percent sodium alginate was equally as firm as that containing 0.35 percent gelatin and was less inclined to appear crumbly. When used in the same percentages virtually the same texture was obtained, showing that the sodium alginate is the more effective in this respect. The ice creams made from this stabilizer melt a bit more freely than those containing gelatin and appear smooth and creamy. If a little too much gelatin is used in an ice cream, the resultant product melts too slowly and looks uneven or "feathered." This is less likely to occur when too much sodium alginate is used.

From the work of the various investigators it may be concluded that sodium alginate can be used satisfactorily to stabilize ice cream. The most practical method of using the stabilizer is to add it, mixed with sugar or dispersed in water, when the mix temperature has reached 160 degrees F. To avoid excessive viscosity, the mix acidity should be normal, the pasteurizing temperature should not be permitted to rise above 165 degrees F., and the holding period should be limited to thirty minutes. After homogenization, the mix should be cooled rapidly to 40 degrees F. The amount of sodium alginate needed depends upon its strength, total solids of the mix, and the degree of stabilization desired.

The Use of Irish Moss as a Stabilizer in Ice Cream

Irish moss is a derivative of a marine plant called *Chondrus Crispus*, or Carrageen, grown off the coast of Ireland, France, the British Isles, and Nova Scotia. Turnbow and Tracy (2()) report that Irish moss has been used for some time as a stabilizer in the cosmetic industry, soaps, paint, in non-settling chocolate milk drinks, textiles and, more recently, in ice cream. The commercial product is likely to be a mixture of chemically treated forms of Irish moss and gum, such as daraya, modified to increase its solubility. Limited studies have been made at the University of Illinois Agricultural Experiment Station by Tracy (28) of a commercial stabilizer composed essentially of four standard varieties of Irish moss. Both 10 and 12 percent mixes were used. The Irish moss was easily incorporated in the mix and produced an immediate viscosity, which increased only slightly upon aging. Mixes containing Irish moss had normal whipping qualities. As little as 0.10 percent produced body effects comparable to those obtained with 0.35 percent gelatin (215 bloom) except that the body was drier and slightly more crumbly. Irish moss did not cause a precipitation of the mix protein and imparted normal melt-down characteristics to the ice cream.

Kragel is a modified Irish moss stabilizer. The use of this product in ice cream has been studied by

Martin and Caulfield (23). When 0.35 percent was used in 12 percent fat mixes, the stabilizing action obtained was comparable to the results secured with 0.35 percent of a 250 bloom gelatin. The product as it is made today, however, is much stronger, so that only 0.20 percent is necessary Kragel is incorporated in the mix in the same manner as gelatin. The pH of the mix is raised slightly. There is an immediate effect upon mix viscosity, which is an advantage for counter freezer mixes. Mixes containing Kragel compare favorably in whipping quality with those containing gelatin.

Dahle and Collins (7) report that the purity of Irish moss is questionable because it often contains fine sand, ground sea shells, and other extraneous matter. The bacterial content may also be high. The stabilizing quality of the product is excellent, but it has the property of producing high initial viscosity in mix which prevents proper cooling. It often causes flaking on the cooler. It is also difficult to disperse in the mix and causes considerable foaming with considerable air remaining in the mix until frozen. As little as 0.08 percent will give good stabilization against ice crystals, however, but will result in a very viscous mix which is difficult to handle.

Irish Moss (Dried Extract)

Mantell (22) reports, that when collected, Irish moss contains about 80 percent of water, dried or water-free substance as containing 65 percent of gelatinous matter, 2 to 3 percent of nitrogen in the form of nitrogen compounds, 0.7 to 1 percent of materials grouped under the name of lipoids, and 10 to 15 percent ash. The ash contains compounds of calcium, potassium, magnesium, chlorine, bromine, iodine, and sulphur. Dahle and Collins (7) report that the dried extract of Irish moss is a very soluble and easily dispersed product. It has been used for years to prevent sedimentation in chocolate milk drinks. As little as 0.08 percent will provide for good mix stabilization; but, like the dried Irish moss, it causes the mix to have a high initial viscosity, so that cooling is delayed. It also causes permanent foam in the mix. This product serves in mixed stabilizers very admirably, and most of the defects mentioned have been eliminated from one proprietary stabilizer containing this product. There are some proprietary stabilizers, however, containing this gum which still cause a high initial viscosity in mixes with the above mentioned characteristics. Irish moss (dried extract) is quite readily identified in mixed stabilizers by the aroma and by the shiny appearance of the individual particles.

Agar-Agar and Its Use as a Stabilizer in Ice Cream

Tseng (33) proposed a definition of agar as "the dried, amorphous, gelatin-like, non-nitrogenous extract from gelidium, and other red algae, being the sulphuric ester of a linear galactan, insoluble in cold water, but soluble in hot water, a dilute neutral solution of which (1 to 2 percent) sets on cooling to a firm gel solidifying at 35 to 50 degrees C. and melting at 90 to 100 degrees C." Tseng (33) reports agar-agar is derived from red marine plants belonging to a class of algae known as Rhodophyceae which grow at depths ranging from the surface to 60 feet below. This plant grows off the coasts of Japan and California. Agar-agar is insoluble in cold water but swells and absorbs large quantities of it. When boiled, it goes into a colloidal system which sets to a firm jelly at higher temperatures than do gelatin solutions of the same concentration.

Agar-agar is not acted upon by the digestive juices and has no food value. In pure form it is tasteless and colorless. Lucas and Gould (19) report that agar-agar may be used satisfactorily in ices and sherbets. Its use in ice cream has been very limited, however, because of the difficulty of dispersing it in the mix and its tendency to produce a crumbly body in the ice cream.

Mantell (22) reports the grades of agar offered in the United States are the domestic products and the three Japanese products: Saghaliena, Kobe, and Yokohama. Saghaliena quality, available commercially since 1915, comes from the Japanese part of Saghalien Island. It is not as elastic as the other Japanese grades, but coagulates better, that is, it has more strength. Saghaliena is imported in only small quantity and its cost is highest of the imported types. Kobe quality is divided into three grades. The standards for the different grades are set each season by the Osaka, Kyoto, and Isinglass Association which embraces all the manufacturers, large and small, who manufacture the Kobe quality included in the Association name. The Kobe quality, which represents about 80 percent of the Japanese output and a far larger proportion of the United States' import, is made under better control than the Yokohama quality. It is better also in color, appearance, and strength, particularly the latter. The Japanese products are available generally as strands, sheets, in shredded form, blocks, and powder. The American product is available as flakes and powder. Commercial agar varies from colorless to gray, yellow, pink, and even black.

Dahlberg (11) in his study reports that agar acts more quickly than gelatin but has a low whipping point, in which respect it is not as good as the natural gums.

Dahlberg (11) in his study reports the use of agar at the rate of 0.2 percent with 0.4 percent gums tragacanth for ices and 0.2 percent for sherbets. Agar is useful as a stabilizer in malted milk, acidophilus milk, and other products. Mantell (22) reports the major non-competitive use of agar has been in the nutrient broth and culture media of the biologist. It is estimated that about one-sixth of the production is consumed in this application

Quince Seed Extract as a Stabilizer in Ice Cream

Hadary and Sommer (13) studied the use of quince seed extract as a stabilizer in ice cream. Quince seeds yield a water-soluble extract containing a complex combination of cellulose or hemicellulose with a polysaccharide which produces arabinose and xylose on hydrolysis. The powdered seed extract is readily soluble in mix at a wide range of temperatures (40 to 160 degrees F.). The stabilizing properties of the quince seed are such that 0.032 percent was found to produce results comparable to those obtained with 0.32 percent 225 bloom gelatin. The quince seed produces an immediate effect upon mix viscosity which does not change to any extent during aging. Mixes stabilized with quince seed extract develop much less viscosity than those containing gelatin. Hadary and Sommer further found

that ice cream stabilized with quince seed does not melt down uniformly as that stabilized with gelatin. The whipping time of quince stabilizer was slightly shorter than that of the gelatin stabilized mixes. Quince gum stabilized ice cream mixes attained their maximum viscosity immediately after processing.

Mantell (22) reports that quince seed gum is of commercial interest because it is water soluble, acts as a stabilizer and thickener, and has demulcent properties. The quince was known as "the golden fruit" in the early history of Greece and in Biblical times. It is a native of the Near East, and is cultivated in southern Asia, Europe, South Africa, and America. The 1940 census of the Department of Agriculture indicates that the United States produced 63,869 bushels in 1939. The principal quince growing states were New York, Michigan, Pennsylvania, and Maryland. The American quince is primarily utilized as a canned fruit or in the manufacture of jellies and preserves.

The Use of Tragacanth Gum as a Stabilizer

Mantell (22) reports the annual United States consumption of tragacanth from 1929 to 1940 about two and one-fourth million pounds, being chiefly imported from Iran and Turkey, with imports also from Russia, Irak, British India, Syria and Palestine. Prior to the World War I, Turkey was the most important source, but for many years now Iran has

supplied the greatest amounts and its products are superior. According to Emery (12) gum tragacanth is obtained as an exudate from various Asiatic or East European species of "Astrocyclus." Tragacanth consists of starch granules, cellulose (the insoluble portion), a series of gum acids of the nature of geddic acid, bossoric acid, nitrogenous matter, and minerals.

Mantell(22) reports that tragacanth appears on the market chiefly as ribbons and flakes, though irregularly oblong or roundish and tortuous vermicular shapes. Powder and aqueous solutions are also offered to the trades. Tragacanth may be more easily pulverized by heating to 50 degrees C. Color varies from white to light brown. It appears that gum tragacanth is not a secretion of the plant, but the result of the transformation of cells of the pith and medullary rays which traverse the ligneous part of the stem and older branches by a process known as gummosis. The gum swells by absorbing water and, due to the pressure in the interior of the stem, forces its way out through cracks or through incisions made to assist the exudation. The best gum is obtained in the cooler districts. Plants are tapped in their second year since the product obtained in the first year's growth is poor and unfit for commercial use. Tragacanth is wholly insoluble in alcohol. Its ability

to swell in water to form a gel of high water content (or conversely of low gum content) and the ability of these gels to give unique viscosity, emulsion stabilizing and demulcant behavior account in large measure for its extensive use. Hydrophilic colloids, such as gum tragacanth, owe their high viscosity to some form of structure in the liquid and, if this structure is broken, the viscosity may be greatly reduced. If a solution shows a reduction in viscosity after shaking and an increase after being permitted to remain undisturbed, and the cycle can be continually repeated, then the solution is said to exhibit thiotropy. Tragacanth gum solutions do show thixotropy. Gum tragacanth was commonly used by early manufacturers of ice cream but became less popular as improved stabilizers became available.

Lucas and Gould (19) found that gum tragacanth, when used in the proportion of 4.5 ounces per 100 pounds of mix (12 percent fat, 10 percent serum solids, and 15 percent sugar), produced satisfactory results.

Arabic Gum

Mantell (22) reports that Arabic gum has been known and used since ancient times. Egyptians used it in making paint colors in 2000 B. C. Gum Arabic in the restricted geographical sense is the material exported chiefly to Europe from Arabia, most of the trade being handled in the

Port of Aden. Only a very small portion of the commercial gum is collected in Arabia. Gum Arabic is from several species of Acacia. The best product comes from Acacia Senegal. Mantell (22) reports that the Acacia gums are composed chiefly of the calcium, magnesium, and potassium salts of Arabic acid. Gum Arabic application is varied, covering such unrelated uses as adhesives, polishes, confectionery, printing textiles, paper size, inks, stabilizer, and in pharmaceuticals. Such wide-spread utilization is based upon a combination of unique physical characteristics and their control. Among the characteristics of gum Arabic according to Mantell (22) are:

1. It is practically completely soluble in water
2. It is insoluble in most other solvents
3. Its aqueous solution is highly viscous
4. Its aqueous solution has a low surface tension
5. Its aqueous solution is a good emulsifying medium
6. It behaves as a protective colloid
7. It does not crystallize
8. It is usually tasteless or possesses only a slight taste
9. It is odorless
10. It is available as a practically colorless to light brown colored material
11. It is essentially a metallic salt of a complex Aragenic acid
12. Its properties may be changed by certain chemical treatments

Tseng (33) reports that there is considerable disagreement among botanists as to the nomenclature and identity of Acacia trees, particularly in reference to species,

subspecies, and varieties. In the broad general sense, gum Arabic is almost any gum which dissolves completely in water to form a sticky mucilage. Gum Arabic is the dried gummy exudation from stems and branches of the genus *Acacia* which are leguminous trees. Lucas and Gould (19) found that gum Arabic produced an ice cream of unsatisfactory texture and that it hastened melting. Its use in frozen dairy products has been very limited.

Karaya Gum

Gum karaya has become an important raw material in the textile, cosmetic, food, and other industries. Mantell (22) reports that gum karaya resembles gum tragacanth in that it swells in cold water to form an opaque gel.

Karaya gum has been used in the United States since the latter part of the 19th century, but the large scale use in the United States dates from World War I when some of the gum sold as tragacanth was really karaya. Karaya gum is less expensive than tragacanth and is superior for certain purposes. Gum karaya is the dried exudation from trees of the *Sterculia Urens*, a native tree of India. Tseng (33) reports that the trees from which karaya is obtained (unlike those that yield gum Arabic and tragacanth) are big, reaching a height of twenty-five to thirty feet,

and their trunks are large with a soft corky structure. The gum is obtainable throughout the year except in the rainy season, and the best quality is obtained during the hot spell from March through the middle of June.

Mantell (22) reports that gum karaya shows an acid pH when in contact with water, and experiments show the gum to be a negative colloid. The viscosity behavior of karaya solutions reflects its usefulness in most of its applications more than any other single property. The degree of water absorption and viscosity of gum karaya varies widely with different shipments. Although it is generally assumed that viscosity is affected by the season of the year in which the gum is tapped and collected and by conditions of growth, there is no assurance that the product of any one section of India or of any particular season of the year will produce a high viscosity gum. Turnbow and Tracy (29) report that karaya gum has been used commercially as a substitute for tragacanth. In its purified form karaya gum has been frequently used in combination with other products in the manufacture of commercial ice cream stabilizers.

Oat Gum

One of the newest gum-type stabilizers to be used in the ice cream industry is Aveeno, or oat gum. Josephson, Dahle, and Patten (17) found that 0.5 percent of this

stabilizer produced as satisfactory results as 0.35 percent gelatin (250 bloom test). Oat gum can be used satisfactorily in conjunction with gelatin in stabilizing ices and sherbets. Oat gum has the advantage of forming in the mix an immediate viscosity which does not change with aging. Turnbow and Tracy (29) report that oat gum has certain antioxidant properties.

Cellulose Derivatives

Tracy, Turnbow and Raffetto (29) report that by treating alpha-cellulose (from cotton or wood) with an alkali, such as sodium hydroxide, and then with dimethyl sulfate or methyl chloride, a product called methylcellulose is formed, which upon washing with water and purifying has definite emulsifying properties. Methylcellulose has been successfully used in pharmaceutical fields as an emulsifying agent.

Clemens and Read (6) report its main advantages over gums are its lack of taste, neutrality, non-fermentability, and ability to dry without becoming sticky. Whereas gelatin forms a gel below and a solution above room temperature (68 degrees F.), methylcellulose forms a solution below and a gel above approximately 113 degrees F. Tracy (28) reports that one of the problems connected with methylcellulose in ice cream is its proper dispersion in the mix.

When the stabilizer is added before pasteurization, particles of it separate on the cooler and in low spots in the pipe lines. Homogenization does not help to prevent this difficulty. The best method to use in adding this stabilizer is to mix with hot water, cool this mixture rapidly, and then add it to the processed and cooled mix. The concentration of methylcellulose in water should not be greater than 5 percent. Josephson and Dahle (17) report that mixes containing methylcellulose usually whey off, indicating that the stabilizer reacts with the protein of the mix. The body of the ice cream is slightly sticky, but the melt-down characteristics appear to be desirable. Josephson, Dahle, and Patton (17) found that methylcellulose at the rate of 0.2 percent raised the body and texture score of the ice cream only 0.1 point as compared with the control sample which contained no stabilizer, whereas 0.35 percent of a 250 bloom gelatin raised the body and texture score 1.2 points.

Surface-tension phenomena, according to Clemens and Read (6), are not responsible for foam formation in solutions containing methylcellulose. In every case a positive absorption of solute at the surface resulted. They conclude, therefore, that foam formation is due to this differential concentration.

Dahle and Collins (7) report that methylcellulose has certain characteristics that make its use as a stabilizer in frozen products worth considering. Changes in the product itself apparently need to be made before it can be judged to be satisfactory.

Turnbow and Tracy (29) report that carboxymethylcellulose is a cellulose derivative obtained in the same manner as methylcellulose, except that chloroacetic acid is used in place of methyl chloride. It is used extensively in the pharmaceutical and textile industries. In Europe the product has been used also in various food industries. It is soluble in both hot and cold water, forming solutions stable to heat. Neither calcium nor magnesium chlorides or sulfates affect the stability of sodium carboxymethylcellulose solutions.

Turnbow and Tracy (29) report that carboxymethylcellulose is compatible with other types of stabilizers such as gum Arabic and tragacanth, sodium alginate, gelatin, pectin, and Irish moss. It has good emulsifying properties also. Tracy and Reuhe (30) report from their investigation that this is a more effective stabilizer than methylcellulose. Dahle and Collins (7) report that the amount needed varies, depending upon the grade used as well as the percentage of total solids in the mix. For a mix containing

37 percent total solids, approximately 0.18 percent of the stabilizer is sufficient. Because of its compatibility with other types of stabilizer, sodium carboxymethylcellulose can be used in ice cream in combination with other stabilizing agents. Turnbow and Tracy (29) report that commercial stabilizers are now available which are principally mixtures of sodium carboxymethylcellulose and such products as gelatin or gum, a shipping agent, and corn sugar.

CHAPTER III

EXPERIMENTAL PROCEDURE

Object of Investigation

The purpose of this investigation was to make a comparative study of various stabilizers from animal or vegetable origin and to determine their efficiency, characteristics and effect upon the ice cream mix and ice cream under practical ice cream plant conditions. The experiments were started July 1947 using eleven commercial stabilizers of animal or vegetable origin or in combination. These stabilizers were compared with a basic stabilizer known to the industry as Dariloid produced from sodium alginate.

Acquisition of Stabilizers

In Table III are the commercial trade names of the stabilizers used in this study and the origin of the principal stabilizing ingredients. The carriers or diluents are not listed. The amount to use was recommended by the research department of the manufacturer and depends upon the concentration of the stabilizer and the total solids content of the mix to be stabilized.

TABLE III

ORIGIN OF STABILIZERS USED AND AMOUNT RECOMMENDED

No.	Commercial Name of Stabilizers	Origin of Stabilizers Used in Experiment	Amount Recommended for Use Percent
1	Dariloid	Sodium Alginate Sea-weed	0.2 - 0.36
2	Kragaleen	Carboxymethylcellulose Irish moss (Ground)	0.8 - 0.10
3	Gelatin	Connective Tissue of Animals	0.2 - 0.5
4	Mixcoid	Locust Bean	0.2 - 0.3
5	Polycoid	Gum-Tragacanth	0.3 - 0.4
6	Permastan	Irish moss (Dried)	0.2 - 0.36
7	Dricoid	Algin modified stearates	0.2 - 0.36
8	Freeztex	Carboxymethylcellulose and Gelatin	0.2 - 0.3
9	Gelox	Carboxymethylcellulose Gum* and Gelatin	0.3 - 0.4
10	Shervel	Carboxymethylcellulose	0.2 - 0.3
11	Body Guard	Pectin - citrus fruits	0.1 - 0.2
12	Aveeno	Oat gum	0.2 - 0.3

*The manufacturer did not indicate the type of gum used in this product.

Method of Procedure

Samples of the various stabilizers were secured from the manufacturers or the commercial companies in sufficient quantities to duplicate the experiment. A standard mix was calculated, consisting of 12 percent fat, 11 percent serum solids, 15 percent sugar and the amount of stabilizer recommended by the manufacturer of the stabilizer. The amount of the stabilizer varied from .08 percent to 0.5 percent, dependent upon the concentration of the stabilizer.

Uniform Mix

Uniform mixes were used throughout the experiments, consisting of 12 percent fat and with 38.5 percent total solids content. The source of fat was from fresh whole milk and sweet butter. The sweet butter was made from good quality cream with an average butter score of eighty-nine as determined by the method of scoring used at the national inter-collegiate dairy products judging contest. The solids-not-fat were from skimmilk powder dried by the spray process and from the serum of the milk. The sugar content was from pure cane sugar.

Processing the Mix

Each stabilizer was used in one portion of the mix after the ice cream mix had been well mixed with all necessary ingredients to assure a uniform mixture. The mix was then divided into two portions, each portion being stabilized according to the recommendations of the manufacturer. Deriloid or sodium alginate, was used in each mix as a comparison to the other stabilizers used in the experiment. Each portion of the mix was then pasteurized at 160 degrees F. for a period of thirty minutes. After pasteurization, the mix was homogenized at a temperature of 160 degrees F. at 2700 lbs. pressure per square inch. After homogenization the ice cream mix was cooled to 30 degrees F. and held three hours before the mix was frozen.

Freezing of the Mix

The ice cream mixes were processed, cooled and held with the same time and temperature for each mix stabilized. The mix was cooled down to 30 degrees F. and held three hours before freezing the ice cream. The ice cream mix was then weighed, from each mix stabilized, into forty-five pound batches. This is the recommended weight for each freezing on a forty-quart duo-dash freezer. Each batch was frozen from the various mixes stabilized, with

the freezing time and whipping time recorded. The ice cream was then weighed, and the weight and volume of the mix recorded. The ice cream was stored in a cold storage room at a temperature of 10 degrees C. for twenty-four hours. After the ice cream had been held twenty-four hours, it was then judged and criticized on the basis of body and texture. Ice cream samples were subjected to three hours heat shock at 40 degrees F. and were put back in cold storage at a temperature of -10 degrees C. The ice cream was then scored again for body and texture score and also for shrinkage. Samples of ice cream were kept for a period of seven days and were judged on the basis of body and texture score as used at the Inter-collegiate dairy products judging contest. All samples of ice cream made from mix with the different stabilizers were stored in quart quantities. Shrinkage and body and texture scores were the two chief characteristics scored in the finished ice cream made from ice cream mix stabilized with different stabilizers.

Viscosity of Ice Cream Mix

The viscosity of a liquid or a semi-solid material is its resistance to flow. Leighton and Williams (20) observed that there are two types of viscosity in an aged

ice cream mix. One type, the apparent viscosity, is the livery condition of the mix which upon agitation breaks down into the other type, or basic viscosity, which when once obtained cannot be further reduced by agitation. Gelatin stabilized ice cream mixes form a gel during the aging period, that period after processing and before freezing, during which the mix is stored at a temperature usually not higher than 40 degrees F. The aging period varies but usually is not less than three hours nor longer than forty-eight hours.

In this study the viscosity was determined by the MacMichael viscosimeter. Viscosity readings of the ice cream mixes with the different stabilizers were determined at various times and temperatures. The first samples of the mix were taken immediately after the mix was homogenized and cooled to 40 degrees F.; then the mix was cooled to 30 degrees F. and a reading taken on the viscosimeter. A sample of the 40 degree F. mix was taken and stored at 40 degrees F. for twenty-four hours and the viscosity scored again. A part of mix was also held twenty-four hours at 30 degrees F. and then checked for viscosity reading. Samples of each ice cream mix with different stabilizers were scored for immediate viscosity and after aging a twenty-four hour period at 40 degrees F. and at 30 degrees F.

Shrinkage of Ice Cream

In this study an attempt was made to determine the influence of stabilizers on shrinkage in ice cream. The shrinkage of ice cream remains one of the most important unsolved and bothersome problems confronting the ice cream manufacturer today. The word unsolved is used advisedly, because it is impossible to predict by any known test or condition whether a given sample of ice cream will shrink or not. It is a common observation that the problem may appear or reappear without any advance warning whatsoever and without any changes being made in the composition of the mix processing procedures.

There is a tendency on the part of the ice cream manufacturer, when the trouble makes its appearance, to change some mix constituent; if the trouble disappears the blame for shrinkage is laid to the particular constituent changed. Stabilizers in particular have been vulnerable to attack as the causative factor for shrinkage. A careful review of the literature, however, reveals much conflicting evidence on this point.

In this study, quart size samples were taken of ice cream made from ice cream mixes stabilized with the various stabilizers used in this study. Each sample was stored immediately after being packaged at the freezer. The

storage temperature was held below zero, varying from -10 degrees to -12 degrees C. The samples were checked after a twenty-four hour period and then subjected to a heat shock and refrozen. The samples were then checked for shrinkage at the end of seven days storage at the below zero temperature. Samples of one quart size were checked from each mix of the same composition containing a different stabilizer.

CHAPTER IV

RESULTS AND DISCUSSION

Processing the Mix

Analysis of the mix. The analysis of the ice cream mix used in determining the effects of various types of stabilizers is recorded in Table IV. Each stabilizer tested was compared with Dariloid, or sodium alginate, in a standard mix. The ice cream mix was made from the same source of ingredients in all trials with the same composition of butterfat and solids-not-fat. The ice cream mix was calculated, mixed uniformly, and divided into two portions. Each portion of the mix was then stabilized with Dariloid and another stabilizer (Table IV). Each portion of the mix was then processed under the same conditions. The same pasteurization temperatures, homogenization pressures, and cooling temperatures were used in all uniform mixes. The acidity of the ice cream mixes used in this experiment were below 0.2 titratable acidity.

The ice cream mixes using different stabilizers had definite characteristics in processing, especially the homogenization of the mix. The ice cream mixes stabilized with stabilizers with a high gum content were more difficult to get through the strainer than those mixes of other origin or with a low gum content.

TABLE IV

THE ANALYSIS OF THE ICE CREAM MIX USED IN DETERMINING
THE EFFECT OF VARIOUS TYPES ON STABILIZERS*
(Experiment 1)

Commercial Name of Stabilizer Used	Percent Stabilizer Used	Origin of Stabilizers	Source of Fat and Serum Solids
Dariloid Kragaleen	.3 .35	Sodium Alginate Irish Moss (Ground) and C. M. C.**	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Gelatin	.3 .3	Sodium Alginate Connective Tissue of Animals	Butter, Whole Milk Cream, Skimmilk, Skimmilk Powder
Dariloid Mixcoid	.3 .35	Sodium Alginate Locust Bean	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Polycoid	.3 .28	Sodium Alginate Gum Tragacanth	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Permastan	.3 .36	Sodium Alginate Irish Moss (Dried) Carrageen	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Dricoid	.3 .3	Sodium Alginate Algin, Modified Stearates	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Freeztex	.3 .3	Sodium Alginate C. M. C., Gelatin	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Gelox	.3 .3	Sodium Alginate C. M. C. and Gum Gelatin	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Shervel	.3 .25	Sodium Alginate C. M. C.	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Body Guard	.3 .25	Sodium Alginate Pectin Fruits	Butter, Whole Milk Skimmilk, Skimmilk Powder
Dariloid Aveeno	.3 .28	Sodium Alginate Oat Gum	Butter, Whole Milk Skimmilk, Skimmilk Powder

* The composition of the mix was 12 percent butterfat,
15 percent sugar, and 11 percent solids not fat.

** Carboxymethylcellulose

TABLE V

THE ANALYSIS OF THE ICE CREAM MIX USED IN DETERMINING
THE EFFECT OF VARIOUS TYPES OF STABILIZERS*
(Experiment 2)

Commercial Name of Stabilizer	Percent Stabilizer Used	Origin of Stabilizers	Source of Fat and Serum Solids
Dariloid	.3	Algin	Butter, Whole Milk
Kragaleen	.35	Irish Moss (Ground) & C.M.C.	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Gelatin	.3	Animal Tissue	Cream, Skimmilk, Skim Powder
Dariloid	.3	Algin	Butter, Whole Milk
Miscoid	.35	Locust Bean	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Polycoid	.28	Gum Tragacanth	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Permastan	.36	Irish Moss	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk,
Dricoid	.3	Algin Modified Stearate	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk,
Freezetex	.3	C.M.C. & Gum Gelatin	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Wholemilk,
Gelox	.3	C.M.C. & Gum Gelatin	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Shervel	.25	C.M.C.	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Body Guard	.25	Pectin, Citrus Fruits	Skimmilk, Skimmilk Powder
Dariloid	.3	Algin	Butter, Whole Milk
Aveeno	.26	Oat Gum	Skimmilk, Skimmilk Powder

*The composition of the mix was 12 percent butterfat, 15 percent sugar, and 11 percent solids not fat.

Freezing of the ice cream mix. A comparison of sodium alginate stabilizer with various stabilizers in freezing of the mix is shown in Table V. Each freezing or batch frozen from a mix stabilized with a particular stabilizer was frozen using approximately the same ammonia back pressure. The influence on freezing time shown in Table V by stabilizers was very little; all the mixes were frozen to the same hardness with each batch frozen. The temperature of the original mix varied slightly and might have had some influence on the freezing time of the mix (Table V). The whipping time was the same in each trial, using two and three minutes for each stabilizer in Experiment I. The ice cream mixes were weighed from each stabilized mix, and the freezing time and whipping time recorded. The ice cream from each freezing was weighed and measured by volume with the percent over-run calculated. In Table V the ice cream mixes stabilized with sodium alginate other than Darilord were consistently higher in over-run, especially Dricoid, and permastan which is from sodium alginate with modified stearates. The mixes stabilized with Irish moss, carboxymethylcellulose, were consistently high in over-run for two and three minute whipping time. The mixes which were stabilized with an origin from gum, gelatin and pectin had lower over-run percentages than those

TABLE VI

A COMPARISON OF SODIUM ALGinate STABILIZER WITH
VARIOUS OTHER STABILIZERS IN FREEZING
ICE CREAM MIXES*
(Experiment 1)

Stabilizer Used	Vol. of Ice Cream (Gals.)	Freezing Time (Min-Sec)	Per- cent Over- run	Ammonia Back Pressure (Lbs.)	o F. Temp. of Mix	Weight of Ice Cream (Lbs.)
Dariloid	8	3 10	60	12	30	44
Kragaleen	9	3 5	80	12	35	45
Dariloid	8.5	4 20	70	14	32	44
Gelatin	8	3 30	60	14	30	46
Dariloid	9	3 10	80	14	30	45
Mixcoid	8.5	3 40	70	12	35	45
Dariloid	9.5	5 5	90	13	26	44
Polycoid	9.5	5 10	90	11	34	45
Dariloid	9.5	5 10	90	13	30	45
Permastan	10	5 10	100	12	32	44
Dariloid	9.5	5 30	90	12	30	44
Dricoid	10.5	5 20	100	13	32	46
Dariloid	8.5	5 20	70	14	32	45
Freeztex	9	5 30	80	13	36	45
Dariloid	9	5 10	80	12	30	44
Gelox	9.5	5 5	90	12	34	46
Dariloid	9	5 10	80	13	30	44
Shervel	9.5	5 20	90	12	34	44
Dariloid	9	5 15	80	12	32	45
Body Guard	9.5	5 20	90	12	34	45
Dariloid	9	5 10	80	12	30	45
Aveeno	8.5	5 30	70	12	32	44

*Whipping time was two minutes and weight of ice cream mix was forty-five pounds in all samples.

TABLE VI

A COMPARISON OF SODIUM ALGINATE STABILIZER
WITH VARIOUS OTHER STABILIZERS IN
FREEZING ICE CREAM MIXES*

(Continued)
Experiment I

Stabilizer Used	Vol. of Ice Cream (Gals.)	Freezing Time (Min-Sec)		Per- cent Over- Run	Ammonia Back Pressure (Lbs.)	° F. Temp. of Mix	Weight of Ice Cream (Lbs.)
Dariloid	9.5	3	30	90	12	30	44
Kragaleen	10.0	3	45	100	12	35	46
Dariloid	10.0	3	45	100	14	32	47
Gelatin	9.0	4	10	90	14	30	46
Dariloid	10.0	4	15	100	14	30	46
Mixcoid	9.5	3	45	90	12	35	44
Dariloid	10.0	4	10	100	14	28	44
Polycoid	9.0	4	22	90	14	34	45
Dariloid	10.0	5	15	100	13	30	45
Permastan	11.0	5	20	110	14	32	46
Dariloid	10.0	5	30	100	13	30	44
Dricoid	11.0	5	35	110	13	30	46
Dariloid	9.5	5	25	90	14	32	44
Freeztex	9.5	5	35	90	14	36	45
Dariloid	10.0	5	20	100	13	30	46
Gelox	10.0	5	10	100	12	34	47
Dariloid	9.5	5	20	90	13	30	44
Shervel	10.0	5	30	100	12	34	46
Dariloid	10.0	5	30	100	14	32	45
Body Guard	9.5	5	20	90	13	34	46
Dariloid	10.0	5	10	100	13	30	45
Aveeno	9.0	5	15	80	13	32	47

* Whipping time was three minutes and weight of ice cream mix was forty-five pounds in all samples.

mixes with stabilizers from algin, Irish moss and cellulose origin (Table V). In Experiment I and Experiment II the weight of the ice cream mix varied slightly due to the inability to obtain all the ice cream from the ice cream freezer after each freezing. The percentage of over-run varied from 80 to 100 percent in the mixes frozen with different stabilizers. However, some influence may be due to the freezing time, which was influenced by the refrigeration or the amount of ammonia back pressure, as shown in Table V. The amount of refrigeration varied slightly in the freezing of these mixes stabilized with different stabilizers, due to conditions beyond control. The data on freezing was obtained on the freezing of the mix from the third and fourth batch, or when the amount of ammonia back pressure was near the optimum during the comparison of the freezing of these ice cream mixes from different stabilizers.

Relationship of Body and Texture

The relationship of body and texture to different stabilizers of the ice cream used in a standard mix are shown in Table VIII. The body and texture effect on ice cream from the mixes with different stabilizers at twenty-four hours did not show a great variation. The ice

TABLE VII

A COMPARISON OF SODIUM ALGINATE STABILIZERS WITH
VARIOUS OTHER STABILIZERS IN FREEZING
ICE CREAM MIXES*
(Experiment)

Stabilizer Used	Vol. of Ice Cream (Gals.)	Freezing Time (Min-Sec)	Per- cent Over- run	Ammonia Back Pressure (Lbs.)	° F. Temp. of Mix	Weight of Ice Cream (Lbs.)
Dariloid	9.5	3 30	90	12	35	44
Kragleen	9.5	3 2	90	12	38	45
Dariloid	9.5	4 5	90	14	30	44
Gelatin	8.5	4 40	70	14	35	45
Dariloid	10.0	3 35	100	12	32	46
Mixcoid	9.5	4 5	80	12	36	44
Dariloid	9.5	4 30	90	12	32	45
Polycoid	9.0	5 10	80	12	35	44
Dariloid	9.5	4 5	90	13	30	46
Permastan	9.5	4 30	90	13	34	46
Dariloid	10.0	3 45	100	13	32	46
Dricoid	11.0	4 5	120	13	34	44
Dariloid	10.0	3 30	100	14	32	45
Freeztex	9.5	4 20	90	14	35	44
Dariloid	9.5	3 20	90	12	30	46
Gelox	9.0	4 30	80	12	32	45
Dariloid	9.5	4 30	90	12	32	46
Shervel	9.5	4 45	90	12	34	46
Dariloid	9.5	4 20	90	12	32	46
Body Guard	9.0	4 30	80	12	32	44
Dariloid	9.5	4 30	90	12	30	46
Aveeno	9.5	4 20	90	12	32	45

*Whipping time was three minutes and the weight of the ice cream mix was forty-five pounds in all samples.

TABLE VIII

THE RELATIONSHIP OF THE BODY AND TEXTURE OF
THE ICE CREAM TO DIFFERENT STABILIZERS
USED IN THE STANDARD ICE CREAM MIX
(Experiment 1)

Commercial Name of Stabilizer Used	Body and Texture Score Before Heat Shock*	Condition of Melt Down	° F. Temp. of Ice Cream Storage	Body and Texture Score After Heat Shock	Condition of Melt Down After Heat Shock
Dariloid	29.5	Smooth	10	29	Smooth
Kragaleen	28.5	Smooth	10	28	More Air Bubbles
Dariloid	29	Smooth	8	29	Smooth
Gelatin	28	Sl. Curdy	8	28	Sl. Curdy
Dariloid	29.5	Smooth	5	29	Sl. Curdy
Mixcoid	28	Curdy	5	28	Curdy
Dariloid	29	Smooth	5	28	Smooth
Polycoid	29.5	Smooth	5	28.5	Sl. Curdy
Dariloid	28.5	Sl. Curdy	10	27.5	Smooth
Permastan	28	Smooth	10	27	Sl. Curdy
Dariloid	28	Smooth	10	27.5	Smooth
Dricoid	30	Smooth	10	29.5	Smooth
Dariloid	29	Smooth	5	28.5	Sl. Curdy
Freeztex	28	Curdy	5	27	Sl. Curdy
Dariloid	29.5	Smooth	5	29	Smooth
Gelox	29.5	Smooth	5	27	Smooth
Dariloid	29.5	Smooth	10	29	Smooth
Shervel	29.5	Smooth	10	27	Smooth
Dariloid	28.5	Smooth	10	28	Smooth
Body Guard	27.5	Whey Separation	10	27	Whey Separation
Dariloid	28.5	Smooth	10	28.5	Smooth
Aveeno	27	Smooth	10	27	Slow Melt

*Time of heat shock was three hours at 40 degrees
in all samples.

TABLE IX

THE RELATIONSHIP OF THE BODY AND TEXTURE OF
THE ICE CREAM TO DIFFERENT STABILIZERS
USED IN THE STANDARD ICE CREAM MIX*
(Experiment 2)

Name of Commercial Stabilizer Used	Body and Texture Score-Before Heat Shock	Condition of Melt-down	Temp. of Ice Cream Storage	Body and Texture Score-After Heat Shock	Condition Melt-Down After Heat Shock
Dariloid	29	Smooth	-10° C.	28.0	Smooth
Kragaleen	28	Smooth	-10° C.	27.0	More Air Bubbles
Dariloid	29	Smooth	-12° C.	28.0	Sl. Curdy
Gelatin	29	Smooth	-12° C.	28.0	Sl. Curdy
Dariloid	28.5	Smooth	-10° C.	28.0	Smooth
Mixcoid	27.0	Curdy	-10° C.	26.0	Sl. Curdy
Dariloid	28.5	Smooth	-10° C.	28.5	Sl. Curdy
Polycoid	27.5	Smooth	-10° C.	26.0	Curdy
Dariloid	28.5	Smooth	-10° C.	28.5	Smooth
Permastan	29	Smooth	-10° C.	27.0	Wheys Off
Dariloid	28.5	Smooth	-10° C.	28	Smooth
Dricoid	30	Smooth	-10° C.	29	Smooth
Dariloid	28.5	Smooth	-10° C.	28	Smooth
Freeztex	27	Sl. Curdy	-10° C.	26	Sl. Curdy
Dariloid	29	Smooth	-10° C.	27.5	Smooth
Gelox	29	Smooth	-10° C.	27	Sl. Curdy
Dariloid	29	Smooth	-12° C.	28	Smooth
Shervel	28.5	Smooth	-12° C.	27	Curdy
Dariloid	28	Sl. Curdy	- 8° C.	27	Sl. Curdy
Body Guard	27	Sl. Curdy	- 8° C.	24	Curdy
Dariloid	28	Smooth	-10° C.	27	Smooth
Aveeno	28	Smooth	-10° C.	25	Curdy

*Time of heat shock was three hours at 40° F. in all Samples

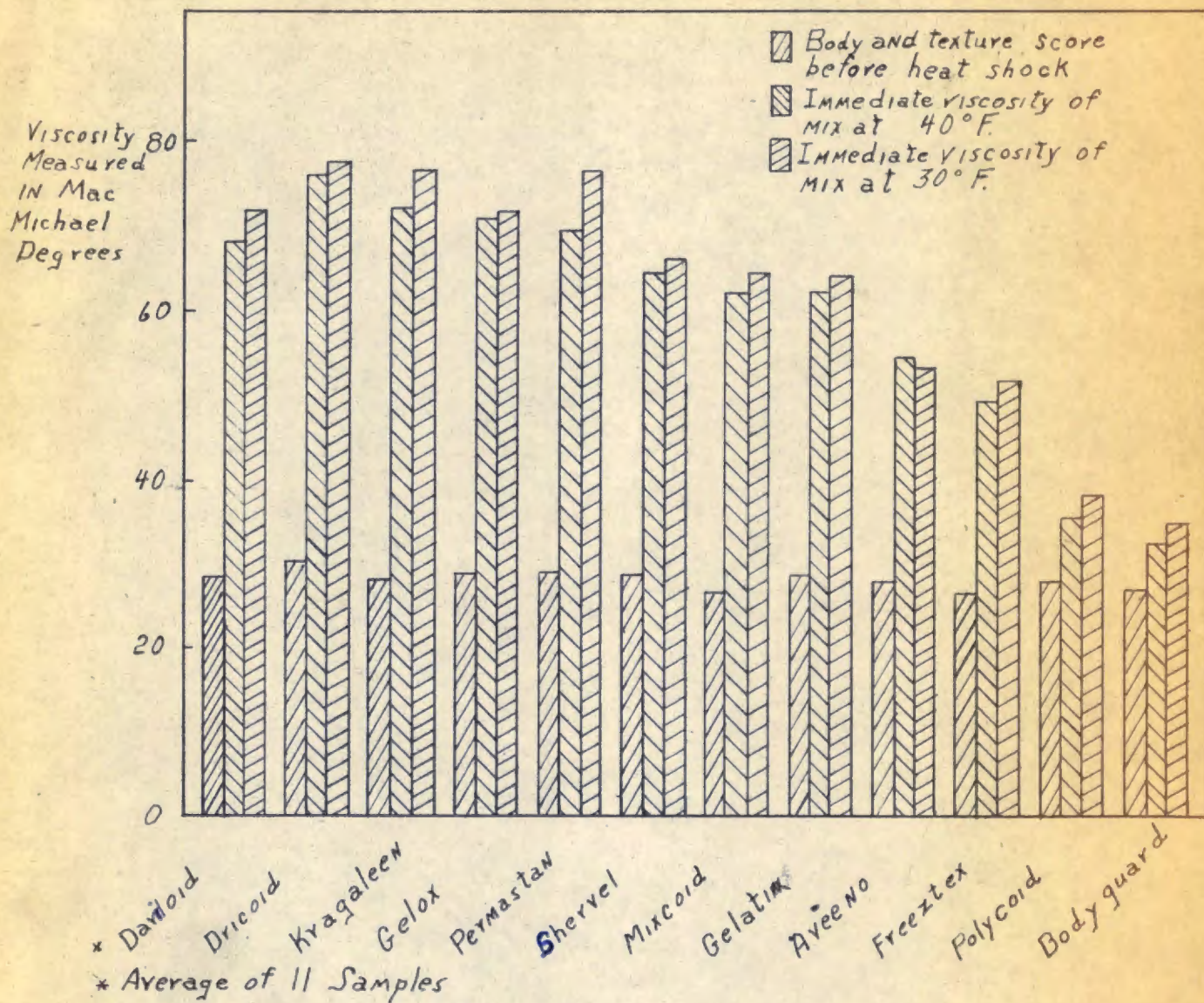


Figure No. 1

A Comparison of Different Stabilizers Used in an Ice Cream Mix to Body and Texture Score of the Ice Cream Before the Heat Shock, and the Viscosity of the Mix Immediately after Processing at 40 Degrees and 30 Degrees Fahrenheit.

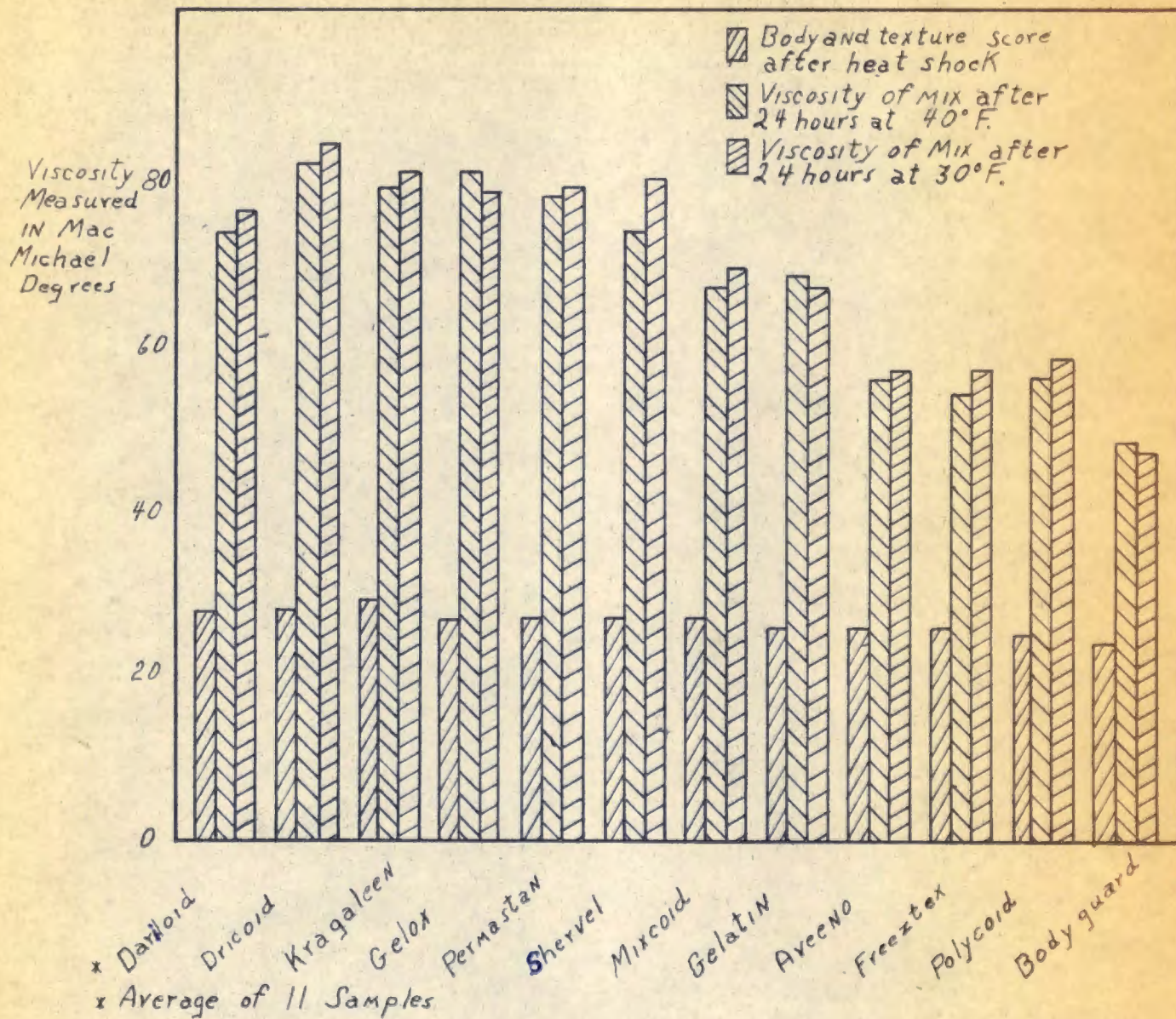


Figure No. 2

A Comparison of Different Stabilizers Used in an Ice Cream Mix to Body and Texture Score of the Ice Cream after the Heat Shock and the Viscosity of the Mix 24 Hours after Processing at 40 Degrees and 30 Degrees Fahrenheit.

TABLE X

THE RELATIONSHIP OF THE EFFECT OF DIFFERENT STABILIZERS
TO SHRINKAGE IN ICE CREAM AFTER TWENTY-FOUR
HOURS AND AFTER SEVEN DAYS*
(Experiment 1)

Commercial Name of Stabilizer	Decrease in Volume After 24 hrs. In Storage	Decrease in Volume After 7 Days in Storage	Temp. Held After Heat Shock **	Temperature of Storage ° C.
Dariloid	None	None	-10° C.	-10° C.
Kragaleen	None	None	-10° C.	-10° C.
Dariloid	None	None	-10° C.	-10° C.
Gelatin	None	None	-10° C.	-10° C.
Dariloid	None	None	-10° C.	-15° C.
Mixcoid	None	None	-10° C.	-15° C.
Dariloid	None	None	- 8° C.	-12° C.
Polycoid	None	None	- 8° C.	-12° C.
Dariloid	None	None	- 5° C.	-10° C.
Permastan	None	None	- 5° C.	-10° C.
Dariloid	None	None	-12° C.	-12° C.
Dricoid	None	None	-12° C.	-12° C.
Dariloid	None	None	-10° C.	- 8° C.
Fræextex	None	None	-10° C.	- 8° C.
Dariloid	None	None	-10° C.	-10° C.
Gelox	None	None	-10° C.	-10° C.
Dariloid	None	None	-10° C.	-12° C.
Shervel	None	None	-10° C.	-12° C.
Dariloid	None	None	-10° C.	-10° C.
Body Guard	None	None	-10° C.	-10° C.
Dariloid	None	None	-12° C.	-10° C.
Aveeno	None	None	-12° C.	-10° C.

*The size of the sample used was one quart.

**The temperature of the heat shock was 42° F. and the time of the heat shock in all samples was three hours.

THE RELATIONSHIP OF THE EFFECT OF DIFFERENT STABILIZERS
TO SHRINKAGE IN ICE CREAM AFTER TWENTY-FOUR
HOURS STORAGE AND AFTER SEVEN DAYS
(Experiment 2)

Commercial Name of Stabilizer	Temp. of Storage	Temp. of Heat Shock	Temp. Held After Heat Shock	Decrease in Volume After 24 Hours Storage	Decrease in Volume After 7 Days Storage
Dariloid	- 8° C.	42° F.	- 8° C.	None	None
Kragaleen	- 8° C.	42° F.	- 8° C.	None	None
Dariloid	-10° C.	42° F.	-10° C.	None	None
Gelatin	-10° C.	42° F.	-10° C.	None	None
Dariloid	-12° C.	42° F.	-12° C.	None	None
Mixcoid	-12° C.	42° F.	-12° C.	None	None
Dariloid	-10° C.	42° F.	-12° C.	None	None
Polycoid	-10° C.	42° F.	-12° C.	None	None
Dariloid	-12° C.	42° F.	-12° C.	None	None
Permastan	-12° C.	42° F.	-12° C.	None	None
Dariloid	-10° C.	42° F.	-10° C.	None	None
Dricoid	-10° C.	42° F.	-10° C.	None	None
Dariloid	-12° C.	42° F.	-10° C.	None	None
Freeztex	-10° C.	42° F.	-10° C.	None	None
Dariloid	-12° C.	42° F.	-10° C.	None	None
Gelox	-10° C.	42° F.	-10° C.	None	None
Dariloid	-12° C.	42° F.	-12° C.	None	None
Shervel	-12° C.	42° F.	-12° C.	None	None
Dariloid	-10° C.	42° F.	-10° C.	None	None
Body Guard	-10° C.	42° F.	-10° C.	None	None
Dariloid	-10° C.	42° F.	-10° C.	None	None
Aveeno	-10° C.	42° F.	-10° C.	None	None

cream was judged according to those used in the Inter-collegiate judging contest.

The ice cream made from mixes stabilized with sodium alginates was consistently in the top range of the body and texture score as shown in Table VI. The ice cream after being subjected to heat shock showed a consistent decrease in body score in Experiments I and II. The ice cream was then held in storage for a period of seven days, but the body and texture score showed only a slight decrease. The ice cream made from mix stabilized with sodium alginates and with derivatives of cellulose decreased less in body and texture score after heat shock and storage than those from other sources (Table VI). The body and texture scores were relatively close as shown in Figure 1 and Figure 2.

Relationship of shrinkage. The relationship of shrinkage in ice cream to stabilizers used in ice cream mix is shown clearly in Table VII. The shrinkage trials in Experiment II do not show any shrinkage either after being subjected to heat shock or at the end of the seven-day period. One quart samples were used from each stabilized mix and subjected to heat shock, refrozen, and then held for a seven-day period. All samples used in this study showed no indication of shrinkage. However, the storage temperatures were below zero, as shown in Table X. The shrinkage test is in agreement with the study

TABLE XII

THE RELATIONSHIP OF VISCOSITY OF THE MIX TO DIFFERENT
STABILIZERS USED IN THE MIX IMMEDIATELY
AFTER PROCESSING AND TWENTY-FOUR HRS.
AFTER PROCESSING AT 30° F. and 40° F.*
(Experiment 1)

Commercial Name of Stabilizer Used	Immediate Viscosity of Mix at 40° F.**	Immediate Viscosity of Mix at 30° F.**	Viscosity of Mix at 40° F.** After 24 Hrs.	Viscosity of Mix at 30° F.** After 24 Hrs.
Dariloid	72.34	74.56	73.26	78.76
Kragaleen	72.10	76.86	81.16	78.65
Dariloid	74.24	76.26	76.41	72.46
Gelatin	62.10	64.26	82.10	84.61
Dariloid	66.38	65.18	68.10	68.76
Mixcoid	62.25	64.32	69.10	67.46
Dariloid	74.26	76.10	79.37	84.56
Polycoid	45.46	48.26	54.36	57.28
Dariloid	63.38	68.23	76.94	76.20
Permastan	69.56	76.30	74.10	80.21
Dariloid	72.28	78.36	73.26	80.10
Dricoid	76.24	77.32	79.46	81.32
Dariloid	56.48	64.40	63.25	74.10
Freezetex	49.32	51.76	56.46	57.38
Dariloid	66.31	68.24	72.10	78.10
Gelox	70.74	71.38	78.10	79.32
Dariloid	74.39	78.60	77.34	81.27
Shervel	64.30	66.28	67.32	69.46
Dariloid	65.82	68.24	74.52	70.21
Body Guard	42.10	44.56	48.27	47.86
Dariloid	70.44	72.69	78.56	79.17
Aveeno	54.60	53.10	56.43	58.40

*The percent of total solids in the ice cream mix was 38.5. The percent fat was twelve.

**Viscosity is measured with MacMichael Viscosimeter and calculated in centipoises.

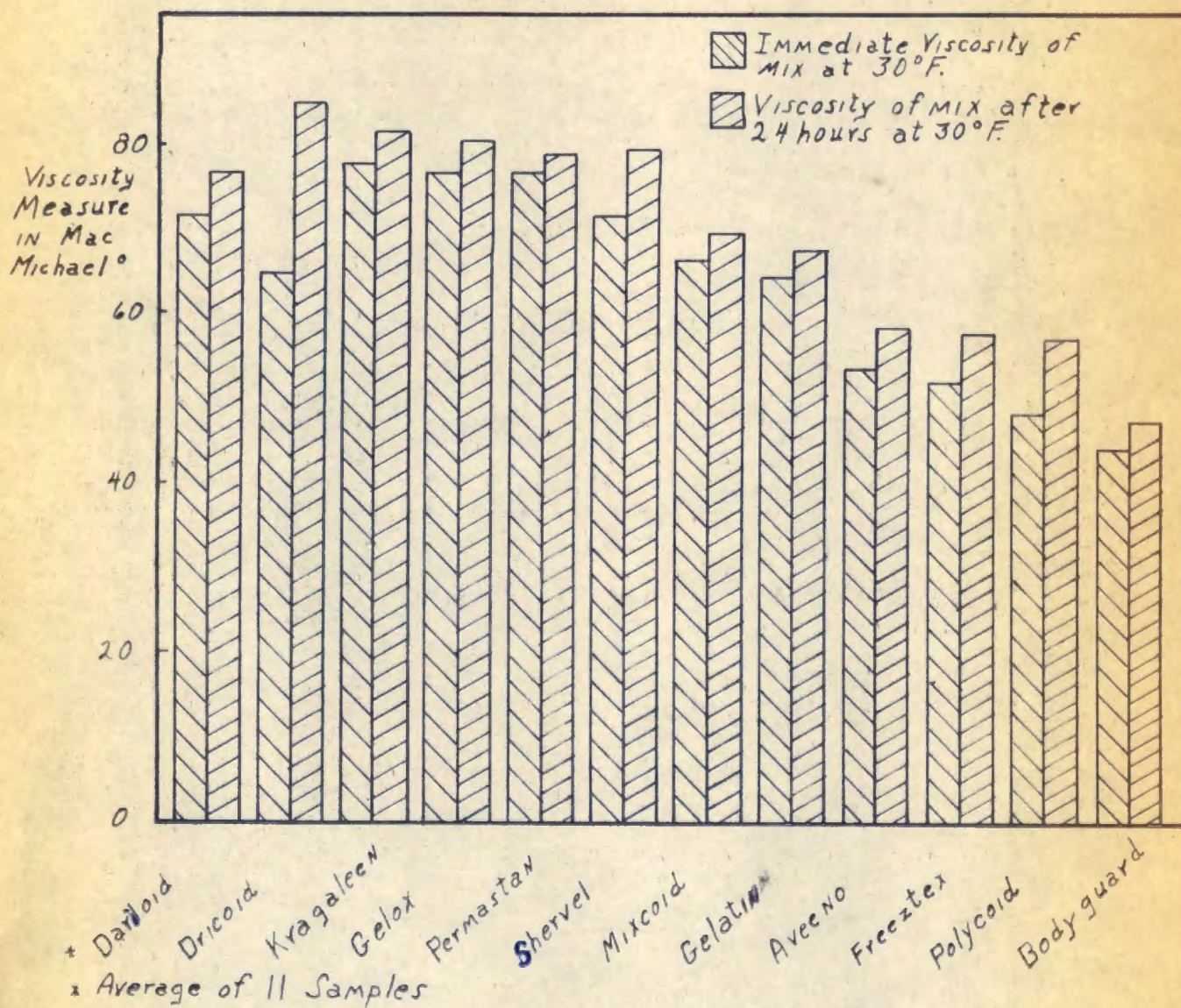


Figure No. 3

A Comparison of the Immediate Viscosity of the Ice Cream Mix and the Viscosity of the Same Mix After 24 Hours at 30 Degrees Fahrenheit with Different Stabilizers Used in the Mix.

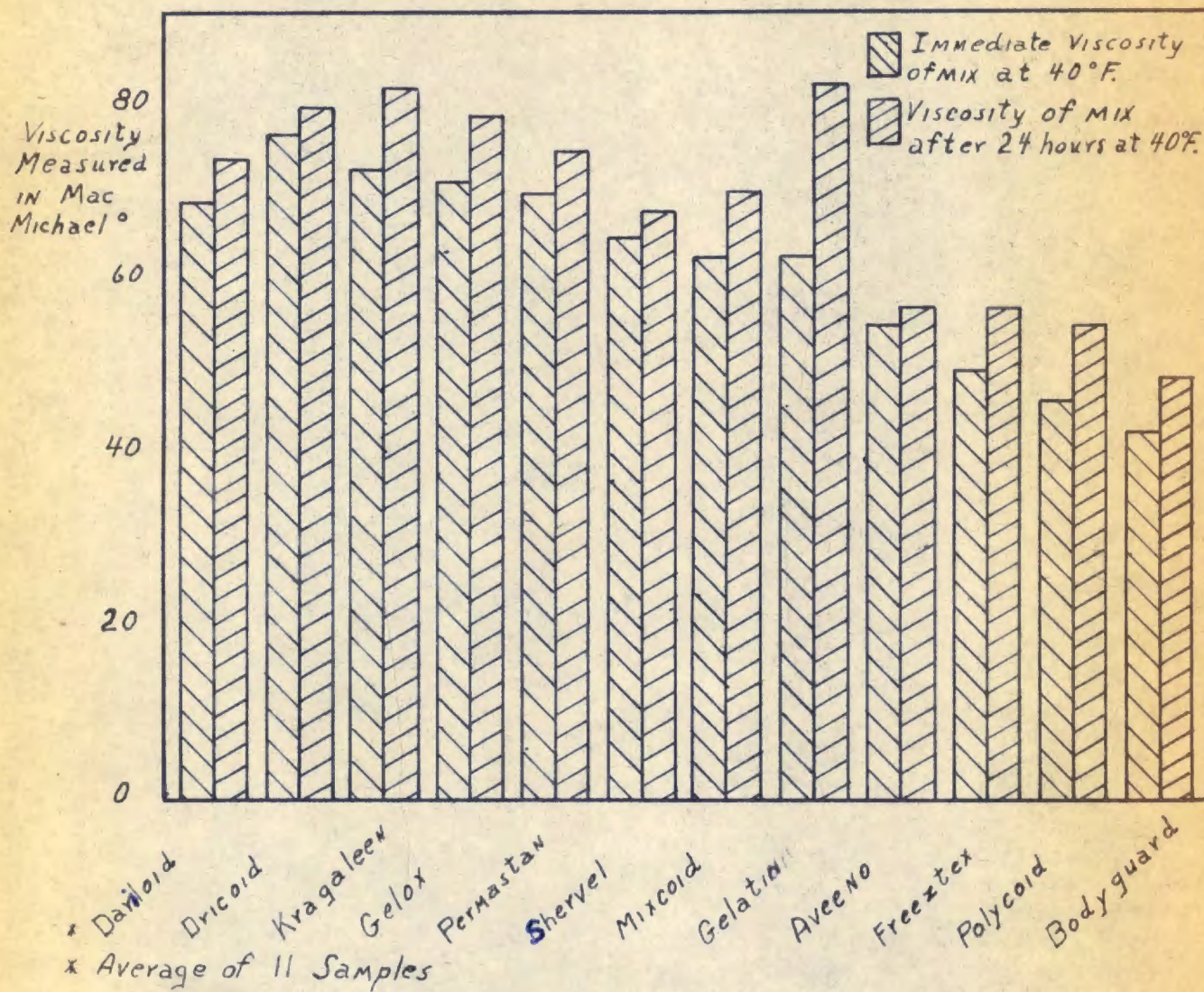


Figure No. 4

A Comparison of the Immediate Viscosity of the Ice Cream Mix and the Viscosity of the Same Mix after 24 Hours at 40 Degrees Fahrenheit with Different Stabilizers Used in the Mix.

of Caulfield (33), who found that stabilizers had no influence on the shrinkage of ice cream.

Viscosity of Ice Cream Mix

The relationship of viscosity of ice cream mix to different stabilizers at 30 degrees F., immediately and at the end of twenty-four hour period, is shown in Table XII, (Experiment II). Viscosity tests were determined by a MacMichael viscosimeter (Figure 5). The viscosity tests show a variation of forty-five to eighty-four centipoises. The ice cream mix showed an increase in viscosity and aging twenty-four hours in all samples, and the viscosity was greater at a lower temperature. The viscosity was greater on the mixes stabilized with gums and gelatin, especially after the gelatin had aged for twenty-four hours. The viscosity of the mix made from stabilizers of pectinic and cellulose origin were lower than those of algin, gum, and Irish moss origin. The relationship of viscosity and body and texture score is shown in Figure 1 and Figure 2. The relationships of immediate viscosity to that after twenty-four hours at 30 degrees F. and at 40 degrees F. are shown in Figure 3 and Figure 4. The relationship of viscosity of ice cream mix to body and texture score was very slight or insignificant. The

viscosity test on ice cream mixes shown in Table XII (Experiment II), indicates a wide variation in resistance to flow from the standpoint of the stabilizers rather than the composition of the mix or the source of the dairy products in the ice cream mix.

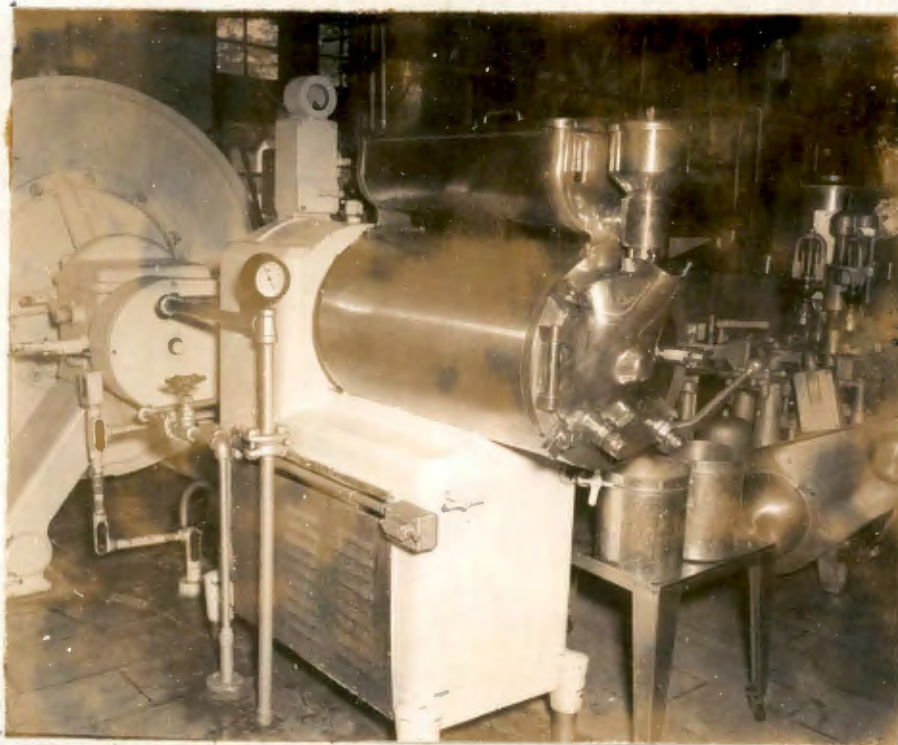


Figure 5

Cherry-Burrell duo-dash ice-cream freezer, 40 quart capacity. The above equipment was used in these experiments.



Figure 6

MacMichael Viscosimeter; used to determine the viscosity tests of the stabilized mixes.

CHAPTER V

SUMMARY

This study was conducted for the purpose of determining the effect and characteristics of stabilizers on ice cream mix and on ice cream, the finished product. Each stabilizer was checked as to its influence on processing, freezing, body and texture, melt-down, shrinkage and viscosity.

The study was divided into two trials or two experiments, in order to obtain a check on the efficiency and effect of the stabilizer on the mix and the finished product. Each stabilizer was compared, through a mix of the same composition, with Dariloid (produced from sodium alginate) as the index. The influence of stabilizers used in this study on the freezing of ice cream mixes was very much alike in the freezing process. There were some variations in the percent of over-run obtained between the various stabilizers. In Table V and Table VI the whipping time was two and three minutes respectively and the ice cream mixes stabilized with Dricoid and Permastan yielded 100 percent over-run, while the other stabilized mixes yielded from 70 to 90 percent over-run. After the whipping time was increased to three minutes, as in Table VI, the percent over-run increased comparatively. The percent over-run

was affected by the kind of stabilizers used, especially if modified steirates were used as in the case of Dricoid, which is produced from sodium alginate.

The relationship of body and texture to different stabilizers used in ice cream mix is quite evident from the data obtained in Table VIII Experiment I, and in Table IX Experiment II. Dricoid, Dariloid, gelatin, Permastan, and Kragaleen were the leading stabilizers used in relationship in body and texture score. The ice cream produced from mixes stabilized with the above mentioned stabilizers decreased less in body score from heat shock and produced ice cream of a very smooth body and texture. The ice cream made from a pectin stabilizer mix was low in body and texture score and wheyed off before and after heat shock.

The relationship and the effect of different stabilizers to shrinkage in ice cream were negative from the data in this study. The ice cream samples were stored at low temperatures, subjected to heat shock, refrozen, and no shrinkage occurred. The data obtained in this study leads one to believe that until more conclusive evidence is produced stabilizers are not important factors in the shrinkage problem

The relationship of the viscosity of the mix to different stabilizers on the body and texture score is shown clearly in Figures 1 and 2. The relationship of

the viscosity of the mix to different stabilizers with respect to age and temperature are shown in Table XII (Experiment II). Figures 1 and 2 indicate that the viscosity of the mix has some influence on the body and texture of the ice cream. The stabilizers of higher viscosity are directly associated with the ice cream scoring higher in body and texture as shown in Figures 1 and 2 in this study.

The data obtained in this study in regard to the effect of the stabilizers used indicate that the ice cream made from mixes stabilized with sodium alginate, cellulose derivatives, and Irish moss are superior to those made from locust bean, gum, tragacanth gum, cat gum, pectin, and animal tissue.

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