A COMPARISON OF THIN WHITE SAUCES PREPARED FROM MIXES CONTAINING DRY MILK SOLIDS

by

LUCILLE BOBBITT PETERSON

B. S., Kansas State University, 1956

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Institutional Management

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1961

TABLE OF CONTENTS

INTRODUCTION

The use of dry milk solids has become increasingly popular in food services. When compared with fluid milk, the cost is considerably less. Dry milk powder can be handled with greater ease than fluid bulk milk and requires less storage space. When stored in the original container with the seal intact, it needs no refrigeration. After the seal has been broken, refrigeration is still not essential if the milk is used in a reasonable length of time.

Recent product developments have influenced the use of both dry whole milk and nonfat dry milk solids. Improved keeping qualities, dispersibility, and flavor have contributed to the increased use of dry milk.

Soups prepared from a white sauce base are used widely in quantity food services, and often are prepared in sufficient amounts for an entire serving period of one to two hours. In hospital food services, soups are a basic menu item for soft and full liquid diets. School lunch programs often serve soups and other products containing milk in order to utilize the nonfat dry milk received as a commodity through the United States Department of Agriculture.

The conventional method for making white sauce involves the preparation of a roux consisting of melted fat and flour, the heating of milk, the incorporation of the hot milk into the roux, and the cooking of the mixture to doneness. A mix from which white sauces can be prepared should be convenient and time saving.

Such a mix might be prepared during slack periods for use at a later time.

The development of whole and instant nonfat dry milk offers increasing opportunities for the use of mixes in quantity food preparation. Longrée and Felt (1954) reported the use of conventional nonfat dry milk in a basic mix from which thin, medium, or thick white sauce was prepared. Thin white sauce prepared from this mix was found to have a lean flavor attributable to the low content of milk solids. Storage life of the mixes was evaluated. Studies of this nature have not been reported in the literature for instant nonfat dry milk or dry whole milk.

The objectives, therefore, of this study were to: (1) develop a mix specifically designed for thin white sauces; (2) compare thin white sauces containing homogenized milk with those made from the instant nonfat dry milk mix and the dry whole milk mix; (3) determine acceptability and holding qualities of thin white sauce prepared from the mixes; and (4) determine changes occurring in the mixes held at refrigerator and at room temperatures for 12 weeks.

REVIEW OF LITERATURE

History of Dry Milk Powders

The commercial development of dry milk has occurred almost entirely within the last 50 years. Although milk in dry form was mentioned by Marco Polo in the 13th century, patents issued during the years between 1897 and 1907 were the basis of the industry that evolved in the next decades. Federal production records before 1916 were not recorded but it appeared that about 2,625,000 pounds of nonfat dry milk and 35,000 pounds of dry whole milk were produced in 1906. As a comparison, production figures for 1957 were reported by Choi (1959) of the American Dry Milk Institute as 1,692 million pounds of nonfat dry milk, 97.3 million pounds of dry whole milk, and 69.2 million pounds of dry buttermilk solids.

Several excellent review articles on the history and development of the dry milk industry have been published in recent years, including articles by Coulter et al. (1951), Johnson (1956), and Choi (1959).

Nonfat Dry Milk

Manufacturing Methods. Two types of drying processes are now used in the production of nonfat dry milk. Of the two processes, the spray method is used more widely than the roller. Generally, spray powder is produced by concentrating the milk in evaporators, and spraying it into the drying chamber by means of a pressurized jet or rotary atomizer. The moisture evaporates from the milk in a matter of seconds after entering the hot air stream passing through the bottom of the chamber, and falls as a fine powder to the bottom of the chamber where it is removed through discharge valves or by suction (Capstick, 1957).

In the roller or drum-drying process, the condensed milk is fed into a trough formed by two rolls revolving in opposite directions and heated by steam under pressure. The speed of rotation and the temperature of the rolls are regulated so that the milk dries in a thin film before the roll completes a revolution. This film is continuously scraped off and pulverized into a fine powder. Choi (1959) explained that the higher heat treatment used in this process resulted in some loss of solubility of the product due to protein coagulation.

Instant Nonfat Dry Milk. A recent development in the dry milk industry, the instantizing process, was designed to improve the dispersibility of spray-process dry milks. Although 99.5 percent soluble in water, spray powder has been difficult to disperse simply and speedily. The particles tended to ball-up and lump together which prevented other particles from making contact with water.

Instant dispersibility was imparted to nonfat dry milk by a process developed by David Peebles. This process has been described by Capstick (1957). The process was designed to produce porous aggregates from the normally fine particles and was accomplished by rewetting the particles with steam. This gave momentary surface stickiness, and the particles adhered at random thereby forming porous aggregates of substantial size and irregular shape. The aggregate particles then were dried by passing over a gently moving shaker dryer through which warm air was delivered from below.

Other methods than that used by Peebles have been developed. One such method was done by means of a special or modified spray dryer, in which drying and agglomeration were accomplished in one operation (Capstick, 1957).

Although instant nonfat dry milk has been established firmly in certain markets, few scientific studies regarding its chemical and physical properties have been reported.

The wettability of instant nonfat dry milk was reported by Bockian et al. (1957) to result mainly from the distribution of salts, lactose and proteins, and the increased particle size. Analysis of successive washings of instant dry milk particles indicated that unlike ordinary dry milk, the readily soluble constituents (salts and lactose) were concentrated on the surface of the dry milk, thus greatly aiding in the dispersibility. The less soluble components, calcium and protein, were oriented toward the center of the particles and were dissolved more readily after the salt and lactose had gone into solution.

A study of the flavor and chemical characteristics of several brands of nonfat dry milk reported by Keeney and Bassette (1957) revealed a variability between brands and between instant and non-instant products. The instant powders exhibited more of the browning reaction than the conventional spray-dried noninstant products. The high relative humidity and elevated temperature used in the instantizing process tended to favor the initial reaction between lactose and milk proteins. This reaction, known as the Maillard reaction, was apt to give end products objectional in flavor and brown in color. The intensity of the browning reaction was correlated with the degree to which the powders were wetted during the instantizing process. A powder which was wetted to 20 percent moisture required more heat and time for redrying, and thus exhibited more browning than a powder which was wetted from 5 to 10 percent moisture. These findings have been confirmed by Kumetat et al. (1957) who analyzed eight samples of instant nonfat dry milk and seven samples of noninstant dry skim milk.

Dry Whole Milk

Manufacturing Process. The dry whole milk currently offered for sale is manufactured almost exclusively by the spray drying process. Kielsmeier (1956) stated that the product prepared with spray driers was difficult to reconstitute with water, had a pronounced cooked flavor, and created an unpleasant chalky sensation in the mouth. Although the instantizing process was successful in the manufacturing of instant nonfat dry milk, the method did not prove suitable for dry whole milk according to Mann (1959). As a result of these solubility and flavor defects, research workers devoted their attention to developing a process to improve the quality of dry whole milk.

Solubility. Dispersibility, reconstitutibility, sinkability, and wettability often are used in the literature to describe the solubility characteristics of dry whole milk powders. Bullock and Winder (1958) defined sinkability as the time taken for powder to sink when placed on a quiescent water surface. Wettability has been described by Litman (1956) as the ability of a dry milk powder to dissolve without stirring. Coulter et al. (1951) stated that the term "solubility" in reference to milk powder was a misnomer as only the lactose and some of the salts were truly soluble.

Baker and co-workers (1959) have presented evidence indicating that the melting point of the fat in a milk powder greatly affected its wettability and dispersibility. These workers prepared samples of dry whole milk containing butter oil with melting points of 19° to 21°, 22° to 24°, and 28° to 30° C. Milk powder which contained the butterfat fraction melting at 19° to 21° C. had approximately the same wettability and dispersibility as commercial instant nonfat dry milk.

Julien and Baker (1957b) demonstrated that the insoluble material from dry whole milk contained 98 percent fat and the soluble fraction contained 42 percent fat and 48 percent protein. Results of Litman and Ashworth (1957) indicated that the solubility of whole milk powder was related to free fat which decreased during storage at 85° F., but was unaffected at 45° F. The relative insolubility of powder at the higher temperature was thought to be due to a complex of free fat and protein, with possible complications attributable to calcium.

Faustova and Boiko (1948) pointed out that condensing and drying procedures significantly altered the pattern of fat distribution, producing an increase in fat particle size with a resultant decrease in solubility and keeping qualities. Studies conducted by Manus and Ashworth (1948) indicated that precondensing milk to a level of 40 percent total solids resulted in a product of higher solubility than when the milk was precondensed to a level of 20 percent solids. Solubility of the powders made from milk precondensed to 40 percent solids did not decrease appreciably when stored for six months at 100^{o} F. Wilster et al. (1946) claimed that the addition of a small amount of sodium citrate as a protein stabilizer to the condensed milk before spraying, produced a powder with improved reconstitutability.

Bullock and Winder (1958) reported that whole milk powder exhibited greatest sinkability when first removed from the drier. Much of this property was lost during the first day or two of storage. Investigations by these workers indicated that by subjecting the powder to a special post-drying temperature treatment, the initial sinkability of the fresh powder could not be retained but could be improved considerably. Storage tests indicated that this property was not lost even after months of storage.

Improved wettability of whole milk powder was obtained by Julien and Baker (1957a) by treatment of the milk, prior to drying, with proteolytic enzymes. The milk enzyme treatment, according to these investigators, affected primarily the surface of the protein molecule, altering its hydrophilic properties, thereby increasing wettability of the powder.

Flavor Stability and Browning. Research work published on stale flavor development in dry milk was reviewed by Coulter et al. (1951). They believed that sufficient information appeared to be available to conclude that the typical flavor of stale dry whole milk was a composite flavor which arose from oxidation of the lipids and the browning reaction. Johnson (1956) explained that early in its history, the dry milk industry learned that the butterfat in dry whole milk was susceptible to oxidation. Thus, by preventing the taking up of iron and copper by the milk; by subjecting the milk to high preheating temperatures; and, by packing the dry product in inert atmospheres; the industry was able to improve the quality of dry whole milk.

In recent work pertaining to quality of raw milk and flavor stability, Ashworth and Prouty (1958) concluded that the temperature of storage of spray-dried whole milk powder had a greater influence on flavor stability than did the bacterial quality of the raw milk.

Discoloration of dry milk powder has not been studied to any great extent. Results of Krienke and Tracy (1946) indicated that discoloration of dry whole milk was related to the temperature and time of exposure during processing and to the moisture content of the powder. As the moisture content of the powder decreased, the extent of browning became less.

Recent Findings Related to Improved Methods of Manufacturing. Morgan et al. (1956) delineated the equipment necessary for the foam-drying process which had been used successfully for drying citrus juices, and mentioned that it probably could be used for drying whole milk.

An entirely new physical form of dry whole milk was developed by workers at the Eastern Regional Research Laboratories in Philadelphia (Sinnamon et al., 1958 and Eskew et al., 1958). The process was referred to as puff-drying or foam-dried and was defined as the formation of a highly expanded, sponge-like structure of dried material from a thin film of concentrated liquid under conditions of high vacuum and low temperatures. The product dispersed rapidly because of its large surface area per unit weight, and possessed natural flavor because of the high-vacuum, low-temperature drying conditions employed. Milk made from this process was found by Sinnamon et al. (1958) to disperse with manual stirring in water at 38° F. in 100 seconds and at 75° F. within 50 seconds. As a comparison, commercial spray-dried milk required over 120 seconds at both temperatures. Eskew et al. (1958) attributed the good dispersibility of the product to: avoidance of protein alteration during processing, as shown by sedimentation patterns of whey proteins; dispersion of fat globules which remain discrete throughout processing and storage; and the distinctive shape of the particles. Workers at the Western Regional Research Laboratories in Davis, California found that the free fat in foam-dried whole milk could be reduced by heating immediately before drying (Tamsma et al., 1958).

Storage studies on foam-dried whole milk indicated that the product could be stored for at least one year at 73° F. according to Eskew et al. (1958). Flavor stability of the product was not mentioned by these workers, but an anonymous article in Hoard's

Digest (1959) claimed that the product was not yet on the market because it absorbed off odors after 9 to 12 weeks at room temperature. Also, the process was expensive.

Kielsmeier (1956) ascribed the defects in dry whole milk to the high temperature employed in the processing operations, and recommended a new approach to the drying of milk. Pasteurized milk, pre-concentrated at a low temperature, was dried in a vacuum plant in which evaporation could be carried out at vapor temperatures of just above 0° C. Due to the development of an oxidized flavor, the powder had a storage life of less than 30 days at room temperature. However, the storage life of the powder could be prolonged to 60 to 80 days by storage at 2° C.

A continuous dehydrator was suggested by Fixari et al. (1959) as applicable to the processing of dry whole milk. This method was used successfully on products which were oxidative-heat sensitive or that required cooling to prevent caramelization after the drying process.

Although at the time of the present study dry whole milk was not produced commercially by any of these methods, it is probable that in the near future one or more of these methods may be used.

White Sauces

Liquid. The liquid used in the preparation of white sauce is milk. The milk may be of different forms: whole milk, homogenized milk, or dried milk solids and water. The conversion of recipes from whole milk to homogenized whole milk created new problems in cookery. Hollender and Weckel (1941) noted that homogenized milk tended to curdle more readily than unhomogenized milk when used in white sauces. Sauces made with homogenized milk were observed by Towson and Trout (1946) to show more fat separation than those made with unhomogenized milk. As the amount of added fat was increased, the size of the fat droplets and apparent amount of separation became greater. Tracy (1948) asserted that milk proteins were destabilized by homogenization, therefore were prone to curdle.

The effect of nonfat dry milk on viscosity and gel strength was studied by Morse et al. (1950a). The gel strength and viscosity of pastes increased as the level of nonfat dry milk solids in the mixture was raised. The increase in viscosity could be adjusted by a reduction in the amount of flour used. The acceptability of white sauces containing nonfat dry milk was tested by Paul and Aldrich (1953) in five women's dormitories at Michigan State University, with favorable reactions in all dormitories. The use of nonfat dry milk solids in a variety of foods has been reported by Morse et al. (1950b). White sauce was tested and found to be acceptable.

Limited work with instant nonfat dry milk in food preparation has been published. Aldrich and Miller (1958) concluded that instant nonfat dry milk could be substituted for conventional nonfat dry milk on a pound-to-pound basis; however, substitution could not be made by measure. The instant nonfat dry milk was less dense than the conventional type, therefore an increased amount was required when substituting by measure.

Flour. Lowe (1955) stated that the kind of flour, and to a great degree its composition, depended upon: the milling process, the classes of wheat from which the flour was milled, and the purpose for which the flour was intended.

The properties of wheat flour long have been recognized to be extremely variable. Gortner (1924) mentioned that certain types of wheat grown under different environmental conditions varied in their water-binding capacity. Flour milled from wheat grown in hot dry seasons was demonstrated by Mangels (1934) to have a lower water-binding capacity than flour produced from wheat grown during seasons of lower temperature and more abundant rainfall. Varieties of wheat differed in water-binding capacity also, according to Bailey (1944).

Bailey (1925) asserted that the water-binding capacity of flour was affected by bleaching compounds and aging, the former more so than the latter. The increase in water-binding capacity might have been due to altered pH or a change in the colloidal condition of gluten, according to the above investigator.

Starches from varieties of common wheat grown in different regions were shown by Mangels (1934) to exhibit consistent variation in viscosity. Rask and Alsberg (1924) indicated that starches of winter wheats had higher viscosities than those of spring wheats. Also, starch pastes made from hard wheat had higher viscosities than those from soft wheat in a study conducted by Anker and Geddes (1944).

Billings et al. (1952) established that the ratio of flour to liquid must be increased when multiplying the size of recipes for cream pie fillings. An increase in proportion of flour to liquid for different batch sizes was necessary to compensate for reduced thickening of the flour. Reduced thickening of the flour was due to slower rate of heating and lower final temperature as the size of the batch was increased. Similar findings in work with white sauces were obtained by Longrée (1953).

Salt. The amount of salt has been considered to affect the quality of white sauce. Morse et al. (1950a) remarked that in thin pastes containing nonfat dry milk, salt increased the viscosity. Towson and Trout (1946) related that increased amounts of salt caused the formation of larger fat droplets in white sauces made with homogenized milk.

Mixes. A mix consisting of nonfat dry milk solids, fat, and pastry or all-purpose flour was developed by Longrée and Felt (1954) for use in institutional food services. White sauces of varying viscosities were prepared from this mix by the addition of specific amounts of water and mix. Thin white sauce prepared from the mix containing pastry flour was declared too lean in flavor to be acceptable. Medium and thick white sauces were acceptable. Sauces made from all-purpose flour were satisfactory at all levels with the exception of very thick sauces.

Storage life of the mixes was investigated in connection with the above study. Mixes were stored in the kitchen at 19° to 27° C. and in a basement storeroom at 16° to 21° C. The results indicated that the shelf life of the mix in the storeroom was 12 weeks, and 8 weeks for those stored in the kitchen.

The average length of cooking time for a one-gallon batch of sauce made from the mix was 35 minutes compared to 53 minutes for an equal quantity of white sauce made from fluid milk. The cost of white sauce made from the mix was considerably less than for that made from fluid milk, at market prices prevailing at that time. These investigators advocated the use of white sauce mixes because of ease of preparation, speed, predictability, and cost.

Recipes for white sauce mixes have been developed by many of the commercial dry milk companies but publication is limited to nonscientific pamphlets for popular consumption.

EXPERIMENTAL PROCEDURE

Preliminary Work

Preliminary work was necessary to develop the formula for the mixes to be used in the main experiment, to standardize techniques of preparation and testing, and to test the recipe for the white sauces containing homogenized whole milk.

The basic formula for white sauce mix using nonfat dry milk developed by Longrée and Felt (1954) was prepared and evaluated. Thin white sauce prepared from this mix was lean in flavor and too thick in consistency in the opinion of the judges. Several variations in the basic mix and in the proportion of mix to water used to prepare thin white sauce were tested. An acceptable product was obtained by reducing the amount of flour in the basic mix, and using the original proportion of mix to water. The sauce prepared from this recipe contained less flour and an increased amount of dry milk solids than the sauce made from the Longrée and Felt (1954) mix.

The adjusted mix next was tested substituting dry whole milk for the instant nonfat dry milk. The white sauce prepared from this mix was acceptable. A mix containing dry sweet cultured buttermilk was tested. The judges indicated that the white sauce prepared from this mix was acceptable, although it appeared somewhat curdled and left an aftertaste in the mouth similar to that of fresh buttermilk. Also the dry buttermilk was more expensive than instant nonfat dry milk or dry whole milk. Therefore, the buttermilk mix was eliminated from the main study.

The formula for the control white sauce containing homogenized milk was adapted from the recipe published by Fowler and West (1950). Methods of preparation and testing were standardized. A short study was made to determine the type of equipment and method of holding white sauces to be used in the main experiment.

The main study consisted of two parts. Part I was designed to: compare thin white sauces containing homogenized milk with those made from the instant nonfat dry milk mix and the dry whole mix; and determine acceptability and holding qualities of thin white sauce prepared from the mixes. Part II was designed to determine changes occurring in the mixes stored at refrigerator and at room temperatures for 12 weeks.

In the interval between completion of Part I and the beginning of Part II, the Department of Institutional Management was moved to a new Home Economics Building, Justin Hall. Due to relocation, the equipment used in the storage study was changed from that used in Part I.

Statistical Design and Analyses

Statistical Design. In Part I, 45 sauces were prepared and tested in 15 periods. A testing period consisted of the preparation and testing of three white sauces. A randomized complete block was used as the statistical design, Table 1. The thin white sauce utilizing dry whole milk was designated as treatment A; that using instant nonfat dry milk as treatment B; and that containing fluid homogenized milk as treatment C. Cooking position on the electric range was randomized as indicated in the statistical design and Plate I.

At each testing period, members of the palatability committee scored four samples of white sauce, one of each of the treatments and a duplicate of one of the products. The treatment which was to be duplicated was selected at random as part of the statistical design (Table 1).

In Part II, after the mixes had been stored for four weeks, a sample of each mix was removed at weekly intervals for 12 weeks and tested. Equipment to be used for the preparation of a given white sauce was determined by the statistical design, Table 2. The mix stored at refrigerator temperature was designated as

Table 1. Statistical design for cooking position on electric range and for presentation of thin white sauces to the palatability committee.

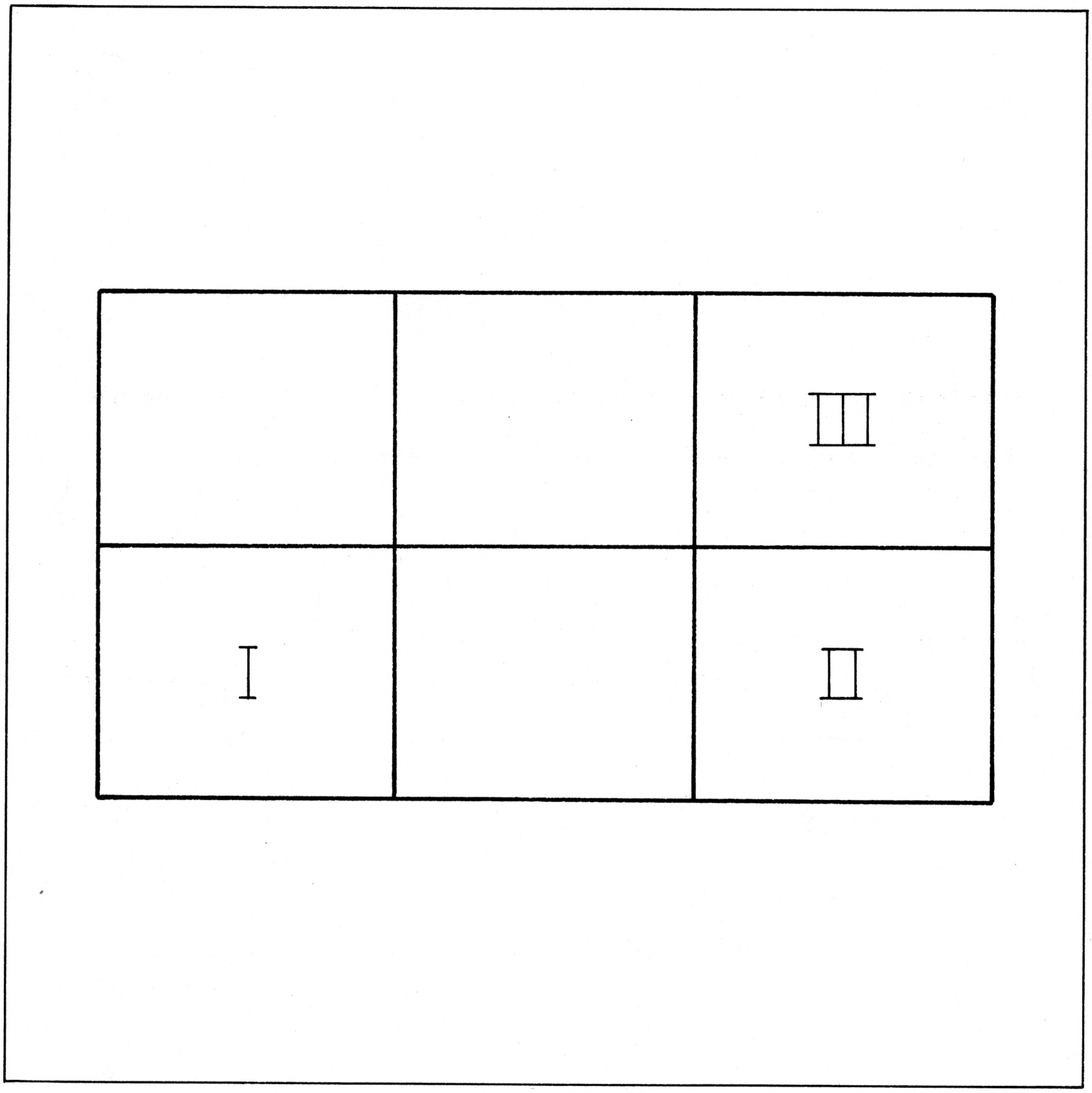
Testing period	Position on electric range: I	II	III	Sample number on score card: 1	2	3	4
1	C	A	B	C	A	A	B
2	B	C	A	B	C	A	B
3	C	B	A	C	B	A	B
4	A	B	C	A	A	B	C
5	A	C	B	A	C	C	B
6	A	C	B	A	C	B	B
7	B	A	C	B	A	C	A
8	B	C	A	B	C	A	A
9	B	C	A	B	C	A	B
10	B	C	A	B	C	A	C
11	C	B	A	C	C	B	A
12	A	C	B	A	C	A	B
13	A	B	C	A	B	C	C
14	B	C	A	B	C	B	A
15	A	C	B	A	C	B	C

A - Dry whole milk.
B - Instant nonfat dry milk.
C - Homogenized milk.

EXPLANATION OF PLATE I

Surface of electric range. I, II, and III represent burners used in preparing white sauce.

PLATE I



treatment I, the freshly prepared mix as treatment II, and that stored at room temperature as treatment III.

Table 2. Statistical design for storage study.[a]

Weeks storage	Instant nonfat dry milk mix			Dry whole milk mix		
	1*	2*	3*	1*	2*	3*
5	II	III	I	II	III	I
6	III	I	II	II	III	I
7	III	II	I	III	II	I
8	I	II	III	I	III	II
9	I	III	II	I	II	III
10	I	III	II	II	III	I
11	II	I	III	I	III	II
12	II	III	I	III	II	I

a - Testing of the mixes stored at room temperature was discontinued after the eighth week.
1* - Electric grill.
2* - Electronic kettle.
3* - Electronic kettle.
I - Refrigerator temperature.
II - Freshly prepared mix.
III - Room temperature.

Statistical Analyses. The data collected in this study were subjected to analyses of variance to determine the effect of using fluid homogenized milk, instant nonfat dry milk, and dry whole milk on the palatability factors, odor, appearance, consistency, curdling, and flavor; and the viscosity as measured by the MacMicheal Viscosimeter.

Analyses of variance were done also to study the effect of using the three treatments on the holding quality of the sauces as measured by viscosity, separation of fat, formation of scum, and curdling.

When significant differences occurred among the three treatments, ordered arrays of means were analyzed by least significant differences.

For each of the treatments, correlation coefficients were determined for viscosity before holding and consistency; viscosity before holding and appearance; viscosity before holding and flavor; viscosity before holding and viscosity after holding; curdling and flavor; and curdling and appearance.

Student's "t" test for paired observations was used to test the significance of differences between duplicate sample scores and initial sample scores.

The data collected on the shelf life of mixes at refrigerator and at room temperatures were subjected to linear regression tests to determine the effect of storage temperature on the shelf life. Student's "t" test was used to study differences in the mixes containing instant nonfat dry milk and those containing dry whole milk when stored at refrigerator temperature.

Procurement and Storage of Ingredients

An attempt was made to have the ingredients as nearly identical as possible. All ingredients excluding homogenized whole milk and butter were obtained in sufficient quantities for all testing periods. All-purpose flour was purchased in 50-pound bags. The dry milk was procured in vacuum sealed cans, six cans to a case. The instant nonfat dry milk was packed in four-and-one-half-pound cans and dry whole milk in four-pound cans. Other ingredients included one-pound boxes of non-iodized table salt, and 50-pound cans of hydrogenated vegetable shortening.

Homogenized whole milk was purchased twice weekly in five-gallon containers from the Kansas State University Dairy. Butter was purchased weekly from the same source. When dry milk solids were used, tap water was the liquid.

The all-purpose flour was stored in a covered stainless steel bin in the laboratory at room temperature. Salt and shortening were stored in the original containers at room temperature. Fluid homogenized milk, dry whole milk, instant nonfat dry milk, and butter were stored at a temperature of approximately 35° to 40° F. in a walk-in refrigerator.

Preparation of Mixes and Thin White Sauces

Preparation of Mixes. Formulas for the mixes are given in Table 3. All ingredients for the mixes were weighed and allowed to remain at room temperature for approximately four hours prior to mixing. A 20-quart Hobart mixer with a pastry blender attachment was used to prepare the mixes. The flour, salt, and milk solids were blended on low speed for 30 seconds. The butter and shortening were added and mixed on low speed for 15 seconds.

Table 3. Formulas for thin white sauces prepared from instant nonfat dry milk mix, dry whole milk mix, and homogenized milk.

Ingredients	Instant nonfat dry milk lb.	Instant nonfat dry milk oz.	Dry whole milk lb.	Dry whole milk oz.	Homogenized milk lb.	Homogenized milk oz.
Flour, all-purpose	2	10	2	10		6
Butter	3		3			6
Shortening, hydrogenated vegetable	3		3			6
Salt		7½		7½		1½
Milk	6		6		12	12
Yield	34 qts.		34 qts.		6 qts.	

The motor then was stopped and the mixer bowl lowered. The bowl and the beater were cleaned of the material that had adhered during the mixing process. Ten strokes with a rubber spatula were used for this process. One stroke was counted for either one straight movement across the bottom of the bowl or one complete circular movement around the sides of the bowl. After this scrape-down process the mixing was continued for an additional 15 seconds at low speed, and the scrape-down process repeated. The ingredients then were mixed for a final 15-second period.

The mixes were placed in one-gallon glass jars with metal lids and stored in the refrigerator at approximately 35° F. until needed. Adequate mix for one week or five testing periods was prepared at one mixing period.

For the storage study, one and one-half times the formula for each of the mixes were prepared. Each mix was divided into two equal quantities and placed in one-gallon glass jars with tight-fitting lids. Half of each batch of mix was stored in the refrigerator at 36° to 48° F. and half was stored at room temperature, 73° to 86° F.

Preparation of Thin White Sauces. Standard equipment for Part I included an institutional size electric range with six elements, balloon-type fine wire whips, and three-gallon aluminum stock pots. The electric heating unit of the range was set on low heat and preheated for 15 minutes.

Equipment used in preparing the white sauces for the storage study consisted of two 10-quart trunnion kettles with electronic controls and a three-gallon aluminum stock pot placed on an electrically heated grill. The thermostats of the electronic kettles were set to maintain a temperature of 184° to 203° F. (90° to 95° C.). The electric grill was preheated for one hour with the thermostat set at 400° F. Immediately after the white sauce was placed on the grill, the thermostat was reset at 350° F. in order to maintain a temperature of 184° to 203° F. in the cooking medium.

White Sauce Prepared From Mixes. In the preparation of white sauce from mixes, 12 pounds 10 and 3/4 ounces (6 quarts) of water was heated in a three-gallon stock pot. When the water reached 90° C., 2 pounds 10 ounces of the mix was added and stirred with a wire whip for 90 seconds. At five-minute intervals during the cooking period the mixture was stirred with a wire whip for 30 seconds to insure even heating. The mixture was cooked until the taste of raw starch disappeared. The cooking time and final cooking temperature were recorded.

White Sauce Prepared From Homogenized Milk. The formula for homogenized milk white sauce is presented in Table 3. In the preparation of white sauce containing homogenized milk, the butter and shortening were melted in a three-gallon stock pot; the flour and salt then were blended into the fat with a wire whip. Approximately one-third of the homogenized milk was stirred gradually into the roux. When the mixture appeared smooth, the remaining liquid was added and stirred with a wire whip for 60 seconds. During the cooking period the mixture was stirred with a wire whip for 30 seconds every five minutes. The mixture was cooked until the taste of raw starch disappeared. The cooking time and final cooking temperature were recorded.

Testing Procedures

Organoleptic Test. After the cooking period, the six members of the palatability committee were given approximately three ounces of each white sauce, served hot in custard cups, on a tray with spoons and a glass of water. Four samples of white sauce were scored by each judge, one of each of the treatments and a duplicate of one of the products. The treatment which was to be duplicated was selected at random as part of the statistical design, Table 1. Using a descriptive numerical score card (Form I, Appendix), the judges assessed the coded samples for odor, appearance, consistency, curdling, and flavor. Scores ranged from five points for excellent quality to one point for poor quality.

In Part II, six judges scored the samples for odor, appearance, consistency, curdling, flavor, and acceptability (Form II, Appendix).

Viscosity. Immediately after preparation, viscosity of the sauces was measured, using a MacMicheal Viscosimeter. Hot water was poured into the outer cup (weight of cup plus water, 500 grams), and the white sauce in the inner cup (weight of cup plus sauce, 240 grams). A spindle plunger supported by a 26-gauge wire was immersed and the cup rotated for 10 seconds. Three readings were taken in MacMicheal units, and an average computed. High readings indicated more viscous samples.

Holding Study

Immediately after preparation, one and one-half quarts of each white sauce were transferred to round stainless steel containers six and one-half inches in diameter and nine inches in depth and placed in an electrically heated Blickman food service cart for the two-hour holding study. The cart had been preheated for one hour with the control set so as to maintain a temperature of approximately 85° C. Temperature of the white sauces was taken at 30-minute intervals during the holding study. At the end of the holding period, viscosity of the sauces was measured in a MacMicheal Viscosimeter, using the same procedure as previously described. Appearance of the sauces was observed and scored (Form III, Appendix).

RESULTS AND DISCUSSION

Observations on the Mixes

Preparation of the Mixes. In this study, the mixes were prepared in a 20-quart Hobart Mixer with a pastry blender attachment. When the dry ingredients and fat were mixed, no differences in the ease of mixing or the ease of manipulation during the scrape-down process were observed between the mixes containing instant nonfat dry milk and the mixes containing dry whole milk. However, some differences in the appearance of the mixes were observed. The mix containing instant nonfat dry milk appeared crumbly in texture, whereas, the mix containing dry whole milk tended to be somewhat more compact.

Ease of Incorporating the Mix. The mixes were incorporated into the hot water, using a balloon-type wire whip. Generally, the instant nonfat dry milk mix was easier to combine with the water than was the dry whole milk mix because the former exhibited less tendency to lump than the latter.

Preparation of the Sauces

End Cooking Point. Tasting for the disappearance of raw starch in cream fillings was reported by Billings et al. (1952) to be a more reliable criterion for determining the end point of cooking than final temperature or time of cooking. In the present work, sauces were considered done when they no longer tasted of raw starch. End-point cooking temperatures of the sauces are presented in Table 4.

Table 4. Average length of cooking time and final cooking temperature for thin white sauces.

Treatments	Average cooking time (minutes)	Average final cooking temperature (° C.)
Treatment A Dry whole milk	28.4	93.7
Treatment B Instant nonfat dry milk	29.1	94.2
Treatment C Homogenized milk	60.9	91.8

Cooking Time. Average length of cooking time for a six-quart batch of sauce made from the mix containing dry whole milk was 28.4 minutes; for the mix containing instant nonfat dry milk, 29.1 minutes; and for the sauces made from homogenized milk, 60.9 minutes (Table 4). An additional six minutes was required to heat hot tap water for the mixes to 90° C.

Palatability Factors

A committee of six judges scored samples of the thin white sauces for odor, appearance, consistency, curdling, and flavor. A scale, ranging from five, best quality; to one, poor quality was used. A summary of the averages of the mean scores for these factors is presented in Table 5. Throughout this study the term consistency was used when referring to the organoleptic tests, and the term viscosity when referring to the objective tests.

Table 5. Average of mean values for palatability factors[1] and viscosity values for thin white sauces made with dry whole milk, instant nonfat dry milk, and homogenized milk.

Factors	lsd	Treatment A Dry whole milk		Treatment B Instant nonfat dry milk		Treatment C Homogenized milk
Odor	0.3	3.3	*	4.0	ns	4.2
Appearance	0.2	4.2	ns	4.3	*	3.8
Consistency	0.4	4.3	ns	4.3	*	3.3
Curdling	0.4	4.4	ns	4.5	*	3.0
Flavor	0.4	3.5	*	4.0	*	3.6
Viscosity[2]	4.9	54	ns	50	*	57

1 - Scoring range, 5 to 1.
2 - MacMicheal units.
* - Significant at the 5 percent level.
ns - Nonsignificant.
lsd - Least significant difference at the 5 percent level.

<u>Odor</u>. The odor of the thin white sauces made with dry whole milk (treatment A), instant nonfat dry milk (treatment B), and homogenized milk (treatment C) received average scores of 3.3, 4.0, and 4.1, respectively. There was a significant difference between the mean odor score for sauces made with dry whole milk and those made with instant nonfat dry milk or homogenized milk (Table 5). On several occasions, the judges commented that the

odor of the sauces made with dry whole milk resembled that of canned evaporated milk.

Appearance, Consistency, and Curdling. In this study, appearance, consistency, and curdling scores for the three treatments were related. Average mean scores for these factors are found in Table 5 and the detailed data in Tables 11 through 13 (Appendix). The sauces made with homogenized milk had a lower score for all three of these factors. Statistical analyses showed that the mean scores of these factors for white sauces made with homogenized milk varied significantly from that for the white sauces made with dry milk, but there were no differences in the mean scores for the white sauces made with instant nonfat dry milk and dry whole milk.

During the preparation of the white sauces it was noted that the sauces containing homogenized milk tended to curdle more easily than the sauces made with dry milk.

Flavor. Flavor mean scores for thin white sauces made by treatments A, B, and C were 3.5, 4.0, and 3.6, respectively (Table 5). Although significant differences were observed between the mean flavor scores for white sauces made with instant nonfat dry milk and those made with dry whole milk or homogenized milk, there were no differences in the mean scores for the white sauces made with homogenized milk and dry whole milk.

Correlation coefficients were calculated from the data for flavor and curdling (Table 6). A highly significant positive

Table 6. Correlation coefficients for certain palatability factors and viscosity.

Factors	Treatment A Dry whole milk	Treatment B Instant non-fat dry milk	Treatment C Homogenized milk
Viscosity and consistency	-.12	.19	-.61**
Viscosity and appearance	-.34	-.10	-.54*
Viscosity and flavor	-.14	-.05	-.75**
Curdling and flavor	.31	.36	.69**
Curdling and appearance	.52*	.34	.67**
Viscosity before holding and viscosity after holding	.80***	.66**	.84***

* Significant at the 5 percent level (13 D/F, r = .51).
** Significant at the 1 percent level (13 D/F, r = .64).
*** Significant at the one-tenth percent level (13 D/F r = .76).

correlation was obtained between these factors for sauces made with homogenized milk. The correlation coefficients for these factors were nonsignificant for sauces made with instant nonfat dry milk and dry whole milk.

Duplicate Sample Scores. The palatability committee judged four samples of white sauce at each testing period, one of each of the treatments and a duplicate of one of the products. The statistical test used to evaluate the differences in the scores between initial samples and duplicates was Student's "t" test.

Values for t and probabilities will be found in Table 7. All t values were nonsignificant, indicating that under the conditions of this study the judges were able to identify correctly duplicate samples.

Table 7. Student's "t" test values for duplicate sample scores as compared to initial sample scores.

Factors	t	D/F	Probability
Odor	.924	14	.30
Appearance	.695	14	.50
Consistency	.366	14	.70
Curdling	.823	14	.40
Flavor	.929	14	.30

Viscosity

The higher the values for viscosity of the white sauces as measured by the MacMicheal Viscosimeter, the thicker the sauces (Table 5). Mean values for viscosity of white sauces given treatments A, B, and C were 54, 50, and 57, respectively. White sauces containing homogenized milk were significantly thicker than those made with dry whole milk or instant nonfat dry milk.

Negative correlation coefficients were noted between viscosity and consistency scores, viscosity and appearance, and viscosity and flavor for white sauces containing homogenized milk (Table 6). Highly significant correlations were obtained for viscosity and flavor and for viscosity and consistency, and a significant correlation coefficient for viscosity and appearance for homogenized milk white sauces. Significant correlation coefficients were not found between these factors for white sauces containing dry whole milk or instant nonfat dry milk.

Holding Qualities

Frequently large quantity food services prepare soups and other dishes containing white sauces in sufficient quantity for an entire serving period of from one to two hours. A two-hour period in an electrically heated hot cart was used in this study to evaluate holding qualities of thin white sauces. Observation of the white sauces for separation of fat, formation of scum, and curdling was used as an indication of holding qualities. It should be pointed out that only the investigator scored the sauces for these factors. Viscosity of the sauces was measured by the MacMicheal Viscosimeter. Average mean scores for these factors are found in Table 8, and the detailed data in Tables 14 to 16 (Appendix).

Thin white sauces were judged for formation of scum, separation of fat, and curdling on the basis of none, some, or much. For purposes of statistical analysis these terms were assigned scores of 5, 3, and 1, respectively.

Average holding temperature during the two-hour period was 87° C. for sauces containing instant nonfat dry milk and dry whole milk, and 85° C. for those made with homogenized milk.

Table 8. Avèrage mean values for factors related to holding qualities for thin white sauces made with dry whole milk, instant nonfat dry milk, and homogenized milk.[1]

Factors	lsd	Treatment A Dry whole milk		Treatment B Instant non-fat dry milk		Treatment C Homogenized milk
Fat separation	0.6	3.5	*	2.6	*	4.6
Formation of scum	--	2.9	ns	3.0	ns	3.0
Curdling	0.7	4.9	ns	4.6	*	3.0
Viscosity	5.5	51	*	41	*	60

1 - Scoring range, 5 to 1.
* - Significant at the 5 percent level.
ns - Nonsignificant.
lsd - Least significant difference at the 5 percent level.

Formation of Scum. No significant differences in average scores for formation of scum attributable to treatment were observed. However, scum which formed on the sauces made with dry milk solids could be dispersed by beating slightly with a wire whip; whereas, scum formed on sauces containing homogenized milk, although broken up, remained in identifiable bits.

Fat Separation. Fat separation, after holding, of thin white sauces made by treatments A, B, and C received mean scores of 3.5, 2.6, and 4.6, respectively (Table 8). A significant difference was found between the mean scores for fat separation for all treatments. Thin white sauces made with homogenized milk received the highest score, followed by those containing dry whole milk. Sauces made with instant nonfat dry milk received the lowest score.

<u>Curdling</u>. Mean scores for curdling after holding may be found in Table 8. Statistical analyses showed that the mean score for curdling after holding for white sauces made with homogenized milk varied significantly from those for white sauces made with dry milk. There were no differences in the mean scores for the white sauces made with instant nonfat dry milk or dry whole milk.

<u>Viscosity</u>. Average mean viscosity scores of the thin white sauces made by treatments A, B, and C were 51, 41, and 60, respectively (Table 8). Significant differences were found between mean scores for all treatments.

Positive correlation coefficients between viscosity before holding and viscosity after holding were obtained for all treatments (Table 6). The correlation coefficients for these two factors for homogenized milk and dry whole milk sauces were very highly significant and highly significant for those made with instant nonfat dry milk.

A trend was noted for white sauces containing homogenized milk to become thicker, and for dry milk sauces to become thinner during the holding period. However, this trend was not statistically significant.

Storage Study

To determine shelf life, mixes were stored at room temperature (23° to 30° C.) and at refrigerator temperature (2° to 9° C.) for 12 weeks. After the mixes had been stored for four weeks, samples of each mix were removed at weekly intervals, made into thin white sauces, tested for viscosity, and scored for appearance, consistency, curdling, flavor, odor, and acceptability. A white sauce made from a freshly prepared mix was used as the control.

Viscosity. In a similar study on shelf life of mixes containing conventional nonfat dry milk, Longrée and Felt (1954) noted a tendency for white sauces made from the mix to become thinner after eight weeks of storage. In the present study, no trend of this nature was observed for sauces stored at refrigerator temperature. Testing of the mixes stored at room temperature was discontinued after eight weeks. Statistical analysis indicated that viscosity values did not show a significant trend when the mix was stored at room temperature for eight weeks and at refrigerator temperature for twelve weeks (Table 9).

Differences between average scores for mixes containing instant nonfat dry milk and those containing dry whole milk were analyzed by the "t" test. No significant differences between viscosity of sauces prepared from the two mixes were noted (Table 10).

Palatability. Sauces made from the mixes stored at room temperature up to six weeks were rated satisfactory or better, but ratings dropped below "medium quality" after six weeks of storage. After eight weeks of storage, all judges rated as unacceptable the sauces made from the mixes stored at room temperature (Tables 17 and 19, Appendix). At this point, testing of these mixes was discontinued.

Table 9. Linear relationship between storage temperature and time on palatability scores and viscosity values for thin white sauces prepared from mixes.

Factors	Dry whole milk mix: Refrigeration vs fresh mix[1]	Dry whole milk mix: Room temperature vs refrigeration[2]	Instant nonfat dry milk mix: Refrigeration vs fresh mix[1]	Instant nonfat dry milk mix: Room temperature vs refrigeration[2]
Odor	0.62	0.97	0.26	13.28**
Appearance	1.82	--	0.63	5.20*
Consistency	0.44	0.38	0.61	4.22
Curdling	0.95	0.85	1.11	1.94
Flavor	1.02	1.18	0.01	5.58*
Viscosity	0.84	0.65	0.12	0.03

1 - 6 D/F, $t_{.05} = 2.45$.
2 - 2 D/F, $t_{.05} = 4.30$.
* - Significant at the 5 percent level.
** - Significant at the 1 percent level.

Although a linear regression test was run on the data, the degrees of freedom were too small to give significant results in most instances. Significant results were obtained only on mixes containing instant nonfat dry milk. Appearance and flavor scores showed a significant trend toward lower scores. Odor scores indicated a highly significant trend (Table 9).

In general, sauces prepared from mixes stored at refrigerator temperatures were scored high after storage for 11 weeks. At the twelfth testing period, three of five judges rated as unacceptable sauces prepared from the dry whole milk mix. Sauces prepared from the instant nonfat dry milk mix continued to receive high scores after 12 weeks storage (Tables 17 and 18, Appendix).

Table 10. Student's "t" test values for instant nonfat dry milk mixes as compared to dry whole milk mixes when stored at refrigerator temperature.

Factors	t^1	Standard error
Odor	0.30	0.22
Appearance	0.99	0.08
Consistency	0.24	0.07
Curdling	0.64	0.14
Flavor	0.84	0.22
Viscosity	0.76	3.39
Significance of t	ns	

1 - 12 D/F, $t_{.05} = 2.18$.

Differences between average palatability scores for mixes containing dry whole milk were analyzed by the "t" test. No significant differences between palatability scores of sauces prepared from the two mixes were noted (Table 10).

Cost

The proportions of the ingredients and their costs for each treatment are summarized in Table 19 (Appendix). Using current market prices (Manhattan, Kansas, November, 1959), the cost of six quarts of thin white sauce prepared by the three treatments was calculated. The cost of the white sauce prepared from the instant nonfat dry milk mix was $0.98; for the dry whole milk mix, $1.27; and for homogenized milk, $1.52. The raw food cost of thin white sauce prepared with homogenized milk was approximately 20 percent higher than that made with the dry whole milk mix, and 55 percent higher than that produced with the instant nonfat dry milk mix. Sauces prepared from the dry whole milk mixes were 29 percent higher than those prepared from instant nonfat dry milk mixes.

SUMMARY

This study was undertaken to: develop a mix specifically designed for thin white sauce; compare thin white sauces containing homogenized milk with those made from instant nonfat dry milk mixes and dry whole milk mixes; determine acceptability and holding qualities of the sauces; and, determine changes occurring in the mixes held at refrigerator and at room temperature for 12 weeks.

The white sauces were cooked in stock pots on an electric range. All sauces were cooked until the taste of raw starch disappeared. Cooking times and end point temperatures were recorded. A palatability committee scored samples of the white sauces for odor, appearance, consistency, curdling, and flavor. Viscosity of the sauces was measured with a MacMicheal Viscosimeter. Holding qualities were observed and scored. The data were subjected to analyses of variance and, where appropriate, least significant differences were determined.

Average length of cooking time for a six-quart batch of sauce made from the mixes was approximately 30 minutes; whereas, approximate cooking time for sauces containing homogenized milk was 60 minutes.

For homogenized milk white sauces, appearance, consistency, and curdling mean scores were significantly lower than mean scores for instant nonfat dry milk sauces and dry whole milk sauces. No significant differences were found between scores for these factors for sauces containing instant nonfat dry milk and those containing dry whole milk. Positive correlation coefficients for appearance and consistency were observed for all treatments, and these coefficients were significant for sauces containing homogenized milk and dry whole milk. During preparation, the sauces containing homogenized milk tended to curdle more easily than sauces made with dry milk.

Odor scores for sauces utilizing dry whole milk were significantly lower than those containing either instant nonfat dry milk or homogenized milk. On several occasions, the judges commented that the odor of the sauces made with dry whole milk resembled that of canned evaporated milk.

For flavor scores, sauces made with instant nonfat dry milk received significantly higher scores than those containing dry whole milk or homogenized milk. No significant differences were apparent in the flavor scores for the sauces made with homogenized milk and dry whole milk. A highly significant positive correlation coefficient between flavor and curdling was found for sauces made with homogenized milk; whereas, nonsignificant positive correlations were observed for these factors for instant nonfat dry milk and dry whole milk sauces.

The palatability committee judged four samples of white sauce at each testing period, one of each of the treatments and a duplicate of one of the products. The data collected were subjected to statistical analyses using Student's "t" test for paired observations. All "t" values were nonsignificant, indicating that in this study the judges were able to identify correctly duplicate samples.

White sauces made with instant nonfat dry milk and dry whole milk showed no significant variation in viscosity as measured by the MacMicheal Viscosimeter. However, they were significantly thinner than sauces containing homogenized milk. Significant negative correlation coefficients were noted between viscosity and consistency, viscosity and appearance, and viscosity and flavor for sauces made with homogenized milk. Nonsignificant negative correlation coefficients were noted for the majority of these factors for dry milk sauces.

Holding qualities of the white sauces were evaluated by observation of fat separation, formation of scum, and curdling. No significant differences in scores for formation of scum attributable to treatment were observed. However, scum that formed on sauces made with dry milk solids could be dispersed by beating with a wire whip; whereas, scum formed on sauces containing homogenized milk remained in identifiable bits after beating.

Thin white sauces made with homogenized milk received the highest score for fat separation; those containing instant nonfat dry milk received the lowest scores. A high score for this factor indicated little or no fat separation.

In this study, curdling during holding was a characteristic of homogenized milk white sauces. Statistical analysis indicated that the average mean score for this factor varied significantly from white sauces made with dry milk.

A trend was noted for white sauces containing homogenized milk to become thicker and for dry milk sauces to become thinner during the holding period. However, this trend was not statistically significant.

A separate study to determine storage life of the mixes was included in this investigation. Mixes were stored at room temperature and at refrigerator temperature for 12 weeks. After four weeks of storage, samples of each mix were removed at weekly intervals, made into thin white sauces, tested for viscosity, and scored for appearance, consistency, curdling, flavor, odor, and acceptability. A white sauce made from a freshly prepared mix was used as the control.

Shelf life of the mix stored at refrigerator temperature was 11 weeks for mixes containing dry whole milk, and at least 12 weeks for instant nonfat dry milk mixes. Mixes stored at room temperature were unacceptable after eight weeks of storage. From the practical viewpoint, these periods were longer than the mix would be stored under average conditions of institutional food preparation.

A marked difference was noted in the raw food cost of sauces made with homogenized milk and those made with the dry milk mixes.

White sauces containing homogenized milk had a raw food cost approximately 55 percent higher than those made with instant nonfat dry milk mix, and 20 percent higher than those made with dry whole milk mix. Sauces prepared from dry whole milk mixes were 29 percent higher than those prepared from instant nonfat dry milk mixes.

CONCLUSIONS

Under the conditions of this study, the following conclusions are drawn:

1. In general, sauces made from instant nonfat dry milk mixes were superior to sauces prepared from dry whole milk mixes or homogenized milk, as judged by the palatability committee.

2. The shelf life of the mix stored at refrigerator temperature was 11 weeks for mixes containing dry whole milk, and at least 12 weeks for instant nonfat dry milk mixes. Mixes stored at room temperature had a shelf life of from six to eight weeks.

3. Thin white sauces made from homogenized milk cost approximately 55 percent more than sauces prepared from instant nonfat dry milk mixes, and 20 percent more than sauces prepared from dry whole milk mixes. Sauces prepared from dry whole milk mixes were 29 percent higher than those made from instant nonfat dry milk mixes.

4. Cooking time for sauces made from mixes was approximately one-half of the time required for sauces prepared from homogenized milk.

RECOMMENDATIONS FOR FURTHER WORK

In further work, it might be of interest to include as a treatment a mix containing conventional nonfat dry milk, as school lunch programs receive this type of dry milk as a commodity. In order to evaluate overall acceptability of the mixes it would be of value to test the mixes at medium and thick white sauce levels. Because concentration of the mixes would be increased at these levels, salt should be omitted from the basic mix. Also, studies testing the white sauces prepared from the mixes in various products would be useful.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Mrs. Marjorie M. Hemphill, Assistant Professor of Institutional Management, for her guidance in this project and for her patience and help in the preparation of this manuscript; to Dr. Grayce Goertz, Professor of Foods and Nutrition, for her help and constructive criticism in the preparation of this manuscript; to Dr. H. C. Fryer, Director of the Statistics Laboratory, for his help with the statistical analysis of the data; and to the members of the palatability committee for their cooperation.

LITERATURE CITED

Aldrich, Pearl, and Grace A. Miller.
A new milky way for your own favorite quantity recipes. Michigan State University Agr. Expt. Sta. Cir. Bul. 225, 1958.

Anker, C. A., and W. F. Geddes.
Gelatinization studies upon wheat and other starches with the amylograph. Cereal Chem. 21: 335-360, 1944.

Ashworth, U. S., and C. C. Prouty.
Effect of raw milk quality on the flavor stability of dried milk. Jour. of Dairy Sci. 41: 709, 1958.

Bailey, C. H.
The chemistry of wheat flour. New York: The Chemical Catalog Co., Inc., 1925, p. 195-227.

______________.
The constituents of wheat and wheat products. New York: Reinhold Publishing Corp., 1944.

Baker, B. E., E. Bertok, and E. R. Samuels.
Studies on milk powders. III. The preparation and properties of milk powders containing low-melting butter oil. Jour. of Dairy Sci. 42: 1038-1044, 1959.

Billings, M. N., A. M. Briant, K. Longrée, and K. Harris.
Cream pie fillings prepared in multiples of an eight-pie batch. Amer. Diet. Assoc. Jour. 28: 228-230, 1952.

Bockian, A. H., G. F. Stewart, and A. L. Tappel.
Factors affecting the dispersibility of "instantly dissolving" dry milks. Food Res. 22: 69-75, 1957.

Bullock, D. H., and W. C. Winder.
A method to improve the sinkability of dried whole milk. Jour. of Dairy Sci. 41: 708-709, 1958.

Capstick, Edward.
Recent developments in milk products manufacture. Soc. of Dairy Tech. Jour. 10: 190-194, 1957.

Choi, R. P.
Dry milk. Processing for specific uses. Cereal Science Today 4: 39-42, 1959.

Coulter, S. T., R. Jenness, and W. F. Geddes.
Physical and chemical aspects of the production, storage and utility of dry milk products. Advances in Food Res. 3: 45-118, 1951.

Eskew, R. K., N. E. Aceto, H. I. Sinnamon, and E. F. Schoppet.
Dispersibility of foam-dried fat-containing milk products. Jour. of Dairy Sci. 41: 753-760, 1958.

Faustova, V., and N. Boiko.
Changes in butterfat dispersion during the concentration and drying of milk. Mol. Prom. (Russia) 19: 31-32, 1948. Original not seen. Abstract in Dairy Science Abstracts 20: 526, 1958.

Fixari, F., W. Conley, and G. Bard.
Continuous high vacuum drying techniques. Food Tech. 13: 217-220, 1959.

Fowler, S. F., and B. B. West.
Food for fifty, Third edition. New York: John Wiley and Sons, Inc., 1950.

Gortner, Ross Aiken.
Viscosity as a measure of gluten quality. Cereal Chem. 1: 75-81, 1924.

Hollender, H., and D. G. Weckel.
Stability of homogenized milk in cooking practice. Food Res. 6: 335-343, 1941.

Johnson, A. H.
Contributions of industrial research in dairy manufacturing. Jour. of Dairy Sci. 39: 804-811, 1956.

Julien, J. P., and B. E. Baker.
Preliminary observations on the effect of slight proteolysis of fluid milk on wettability of the resulting dried milk. Jour. of Dairy Sci. 40: 444-445, 1957a.

____________.
Studies on insoluble fractions isolated from reconstituted whole milk powder. Jour. of Dairy Sci. 40: 605, 1957b.

Keeney, M., and R. Bassette.
Flavor and chemical properties of nonfat dry milk. Jour. of Dairy Sci. 40: 605, 1957.

Kielsmeier, Elwood William.
A new approach to the drying of milk. Dissertation Abstracts 26: 2131, 1956.

Krienke, W. A., and P. H. Tracy.
Factors related to the brown discoloration of powdered whole milk. Jour. of Dairy Sci. 29: 488-489, 1946.

Kumetat, K., R. Beeby, and A. K. Morris.
A note on the reducing groups of "instant" milk powders. Australian Jour. of Dairy Tech. 11: 113-114, 1957.

Litman, I. I.
A study of a fat-protein complex in powdered milk. Dissertation Abstracts 16: 517-518, 1956.

Litman, I. I., and U. S. Ashworth.
Insoluble scum-like materials on reconstituted whole milk powders. Jour. of Dairy Sci. 40: 403-409, 1957.

Longrée, Karla.
Viscosity of white sauces prepared in quantity. Amer. Dietet. Assoc. Jour. 29: 997-1003, 1953.

Longrée, Karla, and Shirley A. Felt.
Quantity white sauce mix. Amer. Dietet. Assoc. Jour. 30: 1131-1134, 1954.

Lowe, Belle.
Experimental cookery from the chemical and physical standpoint, Fourth edition. New York: John Wiley and Sons, Inc., 1955.

Mangels, C. E.
Varietal and regional variation in properties of wheat starches. Cereal Chem. 11: 571-585, 1934.

Mann, E. J.
Dairy products. Food Manufacture 34: 241-246, 1959.

Manus, L. J., and U. S. Ashworth.
The keeping quality, solubility, and density of powdered whole milk in relation to some variations in the manufacturing process. II. Solubility and density. Jour. of Dairy Sci. 31: 935-945, 1948.

Morgan, A. I., Jr., L. F. Ginnette, J. M. Randall, and R. P. Graham. Technique for improving instants. Food Engineering 31: 86-87, Sept. 1956.

Morse, L. M., D. S. Davis, and E. J. Jack.
Use and properties of non-fat dry milk solids in food preparation. I. Effect on viscosity and gel strength. Food Res. 15: 200-215, 1950a.

__________.
Use and properties of non-fat dry milk solids in food preparation. II. Use in typical foods. Food Res. 15: 216-222, 1950b.

Paul, Pauline C., and Pearl J. Aldrich.
Nonfat dry milk solids in food preparation. Amer. Dietet. Assoc. Jour. 29: 234-237, 1953.

Rask, O. S., and C. O. Alsberg.
A viscosimetric study of wheat starches. Cereal Chem. 1: 7-26, 1924.

Report on dry whole milk.
Hoard's Digest 104: 135, 1959.

Sinnamon, H. I., N. C. Aceto, R. K. Eskew, and E. F. Schoppet.
Dry whole milk. I. A new physical form. Jour. of Dairy Sci. 40: 1036-1045, 1958.

Tamsma, A., L. F. Edmondson, and H. E. Vettel.
Free fat in foam-dried whole milk. Jour. of Dairy Sci. 41: 710, 1958.

Towson, A. M., and G. M. Trout.
Some cooking qualities of homogenized milk. II. White sauces. Food Res. 11: 261-273, 1946.

Tracy, P. H.
Homogenized milk problems. Milk Plant Monthly 37: 58-60, June 1948.

Wilster, G. H., O. N. Schreiter, and P. H. Tracy.
Physico-chemical factors affecting the reconstitutability of dry whole milk. Jour. of Dairy Sci. 29: 490-491, 1946.

APPENDIX

FORM I

SCORECARD FOR WHITE SAUCE

Best Quality	5 points
Good Quality	4 points
Medium Quality	3 points
Fair Quality	2 points
Poor Quality	1 point

Date ______________

Judge ______________

Characteristic	Sample A	Sample B	Sample C	Sample D
Odor: Pleasing, no off odor.				
Appearance: No scum or surface skim.				
Consistency: Smooth like whipping cream.				
Curdling: No evidence of curdling.				
Flavor: No raw starch flavor. Distinctive flavor of milk.				

FORM II

SCORECARD FOR WHITE SAUCE

Best Quality	5 points	Date	________
Good Quality	4 points	Judge	________
Medium Quality	3 points		
Fair Quality	2 points		
Poor Quality	1 point		

Characteristic	Sample A	Sample B	Sample C
Odor: Pleasing, no off odor.			
Appearance: No scum or surface skim.			
Consistency: Smooth like whipping cream.			
Curdling: No evidence of curdling.			
Flavor: No raw starch flavor. Distinctive flavor of milk.			
Check if sample is not acceptable.			

FORM III

OBSERVATION FORM USED IN HOLDING STUDY

Testing period	Formula number	Separation of fat			Formation of scum			Curdling		
		None	Some	Much	None	Some	Much	None	Some	Much
	A									
1	B									
	C									
	A									
2	B									
	C									
	A									
3	B									
	C									
	A									
4	B									
	C									
	A									
5	B									
	C									
	A									
6	B									
	C									
	A									
7	B									
	C									
	A									
8	B									
	C									
	A									
9	B									
	C									
	A									
10	B									
	C									
	A									
11	B									
	C									
	A									
12	B									
	C									
	A									
13	B									
	C									
	A									
14	B									
	C									
	A									
15	B									
	C									

For the statistical analysis, none was assigned a score of 5; some was assigned a score of 3; and, much was assigned a score of 1.

Table 11. Average palatability scores for thin white sauces made with dry whole milk.[1]

Treatment A Dry whole milk Testing period	Odor	Appear- ance	Consist- ency	Curdling	Flavor
1	2.8 3.4	3.8 3.4	3.4 3.2	3.2 3.4	3.2 3.8
2	2.8	4.2	4.4	4.2	3.4
3	2.6	4.4	4.2	4.6	4.0
4	4.0 3.6	4.6 4.6	4.8 4.6	4.6 4.4	4.0 3.8
5	3.8	3.8	4.0	4.2	3.8
6	3.6	4.2	4.0	4.2	3.6
7	3.6 4.0	4.2 4.2	4.2 4.4	4.6 4.6	3.4 4.0
8	3.4 3.0	4.0 3.8	4.2 4.4	4.6 4.6	3.6 3.4
9	3.2	3.8	4.4	4.4	3.2
10	3.0	4.6	4.6	4.6	3.4
11	3.3	4.5	4.5	4.8	3.2
12	3.8 3.8	4.5 4.5	4.7 4.5	4.8 4.7	3.5 3.5
13	3.0	4.6	4.6	4.0	3.2
14	3.2	3.8	4.3	4.0	3.5
15	3.7	4.2	4.2	4.7	3.5
Avg.	3.3	4.2	4.3	4.4	3.5

Scoring range, 5 to 1.

1 - In testing periods 1, 4, 7, 8, and 12 the second score denotes duplicate samples and are not included in the averages.

Table 12. Average palatability scores for thin white sauces made with instant nonfat dry milk.[1]

Treatment B Instant nonfat dry milk Testing period	Odor	Appearance	Consistency	Curdling	Flavor
1	4.0	4.2	4.2	4.0	4.0
2	4.2 4.0	4.2 4.4	4.6 4.8	4.8 4.8	4.0 4.0
3	4.2 4.4	4.6 4,6	4.2 4.2	4.8 4.8	4.6 4.6
4	4.6	4.6	4.8	4.6	4.0
5	3.8	3.8	4.0	4.5	3.2
6	3.8 4.0	4.2 4.0	4.0 4.0	4.4 4.4	3.6 3.4
7	4.4	4.4	4.6	4.6	4.4
8	4.2	3.8	3.6	4.6	4.2
9	4.0 4.0	4.4 4.4	4.4 4.4	4.6 4.6	4.4 4.4
10	4.2	4.4	4.2	4.6	4.2
11	4.2	4.5	4.2	4.7	3.8
12	4.5	4.5	4.3	4.7	4.2
13	3.8	4.6	4.8	4.2	4.0
14	4.0 4.2	4.0 4.0	4.7 4.7	4.0 4.0	3.5 3.8
15	3.7	4.0	3.8	4.2	4.3
Avg.	4.0	4.3	4.3	4.5	4.0

Scoring range, 5 to 1.
1 - In testing periods 2, 3, 6, 9, and 14 the second score denotes duplicate samples and are not included in the averages.

Table 13. Average palatability scores for thin white sauces made with homogenized milk.[1]

Treatment C Homogenized milk Testing period	Odor	Appearance	Consistency	Curdling	Flavor
1	3.6	3.8	3.4	3.4	3.4
2	3.6	2.8	2.4	1.4	2.6
3	3.8	3.6	2.8	2.8	3.2
4	3.6	3.0	1.8	1.6	2.0
5	3.8 4.2	3.8 4.0	3.8 3.8	4.0 4.0	3.8 3.8
6	3.6	4.2	3.2	3.0	3.4
7	4.2	4.0	3.8	3.6	3.0
8	4.8	3.4	3.2	3.4	4.2
9	4.0	3.6	3.2	3.0	4.0
10	4.4 4.4	4.6 4.6	3.8 3.8	3.2 3.2	4.0 4.0
11	4.3 4.3	4.5 4.5	3.5 3.7	3.5 3.5	4.0 4.0
12	3.8	4.0	4.5	4.0	4.2
13	3.8 3.8	4.0 4.0	3.4 3.4	2.6 2.4	4.2 4.2
14	4.5	3.7	3.3	2.5	3.7
15	4.5 4.5	4.0 4.0	3.8 3.8	3.7 3.7	4.5 4.5
Avg.	4.1	3.8	3.3	3.0	3.6

Scoring range, 5 to 1.

1 - In testing periods 5, 10, 12, 13, and 15 the second score denotes duplicate samples and are not included in the averages.

Table 14. Viscosity values and holding study scores for thin white sauces made with dry whole milk.

Treatment A Dry whole milk Testing period	Viscosity[1]		Holding study[2]		
	Before holding	After holding	Fat separation	Formation of scum	Curdling
1	46	39	5	3	5
2	71	47	3	3	5
3	60	47	3	3	5
4	35	33	3	3	5
5	54	50	5	1	5
6	46	40	3	1	5
7	70	73	3	3	5
8	75	82	3	3	5
9	52	41	1	3	5
10	40	40	5	3	5
11	62	63	1	3	5
12	36	40	5	3	5
13	59	73	5	3	5
14	77	61	5	3	5
15	33	34	3	5	3
Avg.	54	51	3.5	2.9	4.9

1 - MacMicheal units.
2 - Scoring range, 5 to 1.

Table 15. Viscosity values and holding study scores for thin white sauces made with instant nonfat dry milk.

Treatment B Instant nonfat dry milk Testing period	Viscosity[1]		Holding study[2]		
	Before holding	After holding	Fat separation	Formation of scum	Curdling
1	32	36	3	3	3
2	77	49	3	3	5
3	74	37	3	3	5
4	41	33	1	1	5
5	60	53	3	1	5
6	55	44	3	3	5
7	53	51	3	3	5
8	51	41	3	1	5
9	49	38	3	5	5
10	25	24	1	5	3
11	33	34	1	3	5
12	48	43	3	3	5
13	53	44	3	3	5
14	58	60	3	3	5
15	37	31	3	5	3
Avg.	50	41	2.6	3.0	4.6

1 - MacMicheal units.
2 - Scoring range, 5 to 1.

Table 16. Viscosity values and holding study scores for thin white sauces made with homogenized milk.

Treatment C Homogenized milk: Testing period	Viscosity[1] Before holding	After holding	Holding study[2] Fat separation	Formation of scum	Curdling
1	42	47	5	3	5
2	76	69	5	1	3
3	59	58	5	3	3
4	90	81	3	1	1
5	66	72	5	1	3
6	52	50	5	3	3
7	72	63	5	3	5
8	35	56	5	5	1
9	52	55	5	3	1
10	39	49	5	3	3
11	51	59	3	5	5
12	40	57	5	3	5
13	58	68	5	3	3
14	52	53	5	3	3
15	59	65	3	3	1
Avg.	57	60	4.6	3.0	3.0

1 - MacMicheal units.
2 - Scoring range, 5 to 1.

Table 17. Average palatability scores[1] and viscosity values[2] for thin white sauces containing dry whole milk, prepared from mixes stored at refrigerator temperature and room temperature, and a freshly prepared mix.

Week	Treatment A Refrigerator temperature							Treatment B Freshly prepared mix							Treatment C Room temperature						
	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity
5	4.8	4.8	4.2	3.8	4.2	0	57	4.0	4.8	4.2	3.4	4.6	0	31	4.4	4.8	4.2	4.2	4.4	0	74
6	4.3	4.5	4.2	4.3	4.8	0	45	4.0	4.5	4.4	4.5	4.3	0	49	3.3	4.5	4.0	4.5	3.2	1	41
7	2.5	4.5	4.3	4.7	2.5	0	51	4.7	4.3	4.3	4.7	4.5	0	40	2.5	4.5	4.3	4.5	2.7	2	19
8	4.0	4.2	4.3	4.0	4.2	0	33	4.0	4.3	4.2	4.3	3.8	0	45	2.0	4.2	4.3	4.2	1.3	6	37
9	3.5	4.5	4.5	4.5	3.7	0	42	3.8	4.7	4.5	4.8	4.7	0	51							
10	3.5	4.3	4.3	4.7	3.7	0	61	4.8	4.7	4.5	4.8	4.8	0	37							
11	4.4	5.0	4.6	5.0	5.0	0	68	3.8	4.8	4.4	4.6	4.6	0	55							
12	3.6	3.6	3.8	4.4	2.0	3[a]	61	4.6	4.8	4.4	5.0	4.8	0	25							

1 - Scoring range, 5 to 1.
2 - MacMicheal units.
3 - Number of judges indicating sauces were not acceptable.
a - Five judges present for testing.

Table 18. Average palatability scores[1] and viscosity values[2] for thin white sauces containing instant nonfat dry milk, prepared from mixes stored at refrigerator temperature and room temperature, and a freshly prepared mix.

	Treatment A Refrigerator temperature							Treatment B Freshly prepared mix							Treatment C Room temperature						
Week	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity	Odor	Appearance	Consistency	Curdling	Flavor	Acceptability[3]	Viscosity
5	4.0	4.7	4.0	4.2	3.8	0	43	4.3	4.7	3.2	2.7	4.7	0	50	4.2	4.7	4.2	4.0	3.7	0	44
6	4.8	4.6	4.0	4.6	4.8	0	62	4.4	4.6	4.2	4.8	4.0	0	34	3.8	4.2	4.2	4.6	3.2	0	35
7	4.3	4.5	4.2	4.8	4.0	0	37	4.5	4.7	4.5	4.8	4.7	0.7	39	2.5	4.0	4.0	4.7	1.8	4	42
8	3.8	4.0	4.2	3.5	4.0	0	42	4.2	4.5	4.0	4.7	4.3	0	41	1.2	3.3	3.7	4.7	1.2	6	33
9	4.8	5.0	4.8	5.0	4.8	0	50	2.8	4.6	4.6	4.2	3.8	0	39							
10	4.8	5.0	4.8	4.8	4.8	0	37	4.6	5.0	5.0	5.0	4.6	0	45							
11	4.2	5.0	4.0	4.2	3.6	0	58	5.0	5.0	4.0	4.6	4.6	0	49							
12	4.4	4.4	4.6	4.6	4.6	0	44	4.8	5.0	4.4	4.8	4.8	0	39							

1 - Scoring range, 5 to 1.
2 - MacMicheal units.
3 - Number of judges indicating sauces were not acceptable.

Table 19. Raw food costs[1] of thin white sauces prepared from mixes containing instant nonfat dry milk and dry whole milk, and from homogenized milk.

Ingredients	Treatment: A Dry whole milk mix — Amount	Cost	B Instant nonfat dry milk — Amount	Cost	C Homogenized milk — Amount	Cost
Flour, all-purpose	2 lb. 10 oz.	$0.216	2 lb. 10 oz.	$0.216	12 oz.	$0.061
Butter	3 lb.	2.100	3 lb.	2.100	6 oz.	.264
Shortening, hydrogenated vegetable	3 lb.	.645	3 lb.	.645	6 oz.	.080
Salt, non-iodized	7½ oz.	.035	7½ oz.	.035	1½ oz.	.007
Milk	6 lb.	4.332	6 lb.	2.682	6 qt.	1.110
Total cost of mixes		7.328		5.678		
Total cost of 6 quarts of thin white sauce		1.270		.984		1.522

1 - Manhattan, Kansas, November, 1959.

A COMPARISON OF THIN WHITE SAUCES PREPARED FROM MIXES CONTAINING DRY MILK SOLIDS

by

LUCILLE BOBBITT PETERSON

B. S., Kansas State University, 1956

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Institutional Management

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1961

This study was undertaken to: develop a mix specifically designed for thin white sauce; compare thin white sauces containing homogenized milk with those made from instant nonfat dry milk mixes and dry whole milk mixes; determine acceptability and holding qualities of the sauces; and, determine changes occurring in the mixes held at room temperature for 12 weeks.

The white sauces were cooked in stock pots on an electric range. All sauces were cooked until the taste of raw starch disappeared. Cooking times and end point temperatures were recorded. A palatability committee scored samples of the white sauces for odor, appearance, consistency, curdling, and flavor. Viscosity of the sauces was measured with a MacMicheal Viscosimeter. Holding qualities were observed and scored. The data were subjected to analyses of variance and, where appropriate, least significant differences were determined.

Average length of cooking time for a six-quart batch of sauce made from the mixes was approximately 30 minutes; whereas, approximate cooking time for sauces containing homogenized milk was 60 minutes.

For homogenized milk white sauces, appearance, consistency, and curdling mean scores were significantly lower than mean scores for instant nonfat dry milk sauces and dry whole milk sauces. No significant differences were found between scores for these factors for sauces containing instant nonfat dry milk and those containing dry whole milk. Positive correlation coefficients for appearance and consistency were observed for all treatments, and these coefficients were significant for sauces containing homogenized milk and dry whole milk. During preparation, sauces containing homogenized milk tended to curdle more easily than sauces made with dry milk.

Odor scores for sauces containing dry whole milk were significantly lower than those utilizing either instant nonfat dry milk or homogenized milk. On several occasions, the judges commented that the odor of the sauces made with dry whole milk resembled that of canned evaporated milk.

For flavor scores, sauces made with instant nonfat dry milk received significantly higher scores than those containing dry whole milk or homogenized milk. No significant differences were apparent in the flavor scores for the sauces made with homogenized milk and dry whole milk. A highly significant positive correlation coefficient between flavor and curdling was found for sauces made with homogenized milk; whereas, nonsignificant positive correlations were observed for these factors for instant nonfat dry milk and dry whole milk sauces.

The palatability committee judged four samples of white sauce at each testing period, one of each of the treatments and a duplicate of one of the products. The data collected were subjected to a statistical analyses using Student's "t" test for paired observations. All "t" values were nonsignificant, indicating that in this study the judges were able to identify correctly duplicate samples.

White sauces made with instant nonfat dry milk and dry whole milk showed no significant variation in viscosity as measured by the MacMicheal Viscosimeter. However, they were significantly thinner than sauces containing homogenized milk. Significant negative correlation coefficients were noted between viscosity and consistency, viscosity and appearance, and viscosity and flavor for sauces made with homogenized milk. Nonsignificant negative correlation coefficients were noted for the majority of these factors for dry milk sauces.

Holding qualities of the white sauces were evaluated by observation of fat separation, formation of scum, and curdling. No significant differences in scores for formation of scum attributable to treatment were observed. However, scum that formed on sauces made with dry milk solids could be dispersed by beating with a wire whip; whereas, scum formed on sauces containing homogenized milk remained in identifiable bits after beating.

Thin white sauces made with homogenized milk received the highest score for fat separation; those containing instrnt nonfat dry milk received the lowest scores. A high score for this factor indicated little or no fat separation.

In this study, curdling during holding was a characteristic of homogenized milk white sauces. Statistical analysis indicated that the average mean score for this factor varied significantly from the white sauces made with dry milk.

A trend was noted for white sauces containing homogenized milk to become thicker and for dry milk sauces to become thinner during the holding period. However, this trend was not statistically significant.

A separate study to determine storage life of the mixes was included in this investigation. Mixes were stored at room temperature and at refrigerator temperature for 12 weeks. After four weeks of storage, samples of each mix were removed at weekly intervals, made into thin white sauces, tested for viscosity, and scored for appearance, consistency, curdling, flavor, odor, and acceptability. A white sauce made from a freshly prepared mix was used as the control.

Shelf life of the mix stored at refrigerator temperature was 11 weeks for mixes containing dry whole milk, and at least 12 weeks for instant nonfat dry milk mixes. Mixes stored at room temperature were unacceptable after eight weeks of storage. From the practical viewpoint, these periods were longer than the mix would be stored under average conditions of institutional food preparation.

A marked difference was noted in the raw food cost of sauces made with homogenized milk and those made with dry milk mixes. White sauces containing homogenized milk had a raw food cost approximately 55 percent higher than those made with instant nonfat dry milk mix, and 20 percent higher than those made with dry whole milk mix. Sauces prepared from dry whole milk mixes were 29 percent higher than those prepared from instant nonfat dry milk mixes.