SOFT-SERVE ICE MILK A UNITED STATES DEPARTMENT OF AGRICULTURE BONUS COMMODITY PRODUCT FOR USE IN THE NATIONAL SCHOOL LUNCH PROGRAM

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Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1986

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Thesis Approved

Thesis Adviser

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ACKNOWLEDGMENTS

Sincere appreciation is extended to Dr. Lea Ebro for her guidance and encouragement throughout my graduate studies and the research project. I also express my appreciation to Dr. Esther Winterfeldt, Dr. Stanley Gilliland, Dr. Beulah Hirschlein, and Dr. Richard Dodder for their assistance with the research project.

A special note of thanks goes to Dr. John Martinez for giving unselfishly of his time and expertise in analyzing the data, to Professor Jack Orr for his assistance in the bacteriological analysis, to Maria Borah for preparing the computer program, and to Bonnie Bowman of the Lawton Public Schools for providing the nonfat dry milk and butter to the project.

Grateful appreciation is extended to my students, to the Lawton Public school foodservice personnel, and to my colleagues at Cameron University. The services and support provided by these individuals contributed greatly to the research project.

Deepest thanks are offered to my family, my husband Joe and my children Tri and Leslie, whose support and encouragement made this goal possible.

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THE RESEARCH PROBLEM

Introduction

The National School Lunch Program (NSLP) was enacted on June 4, 1946 by the Food and Nutrition Service of the United States Department of Agriculture (USDA) The objectives were to safeguard the health and well being of the Nation's children and to encourage the domestic consumption of nutritious agricultural commodities by providing an adequate supply of foods and other facilities in the establishment and maintenance of a non-profit school lunch program (United States Statutes at Large, 1946)

Funds for the NSLP come from federal cash reimbursements and agricultural commodity donations, state and local monies, and children's payments In 1982, Federal cash and commodity donations accounted for 51 4 percent of the total NSLP budget, local and children's payments provided 20 2 and 28 4 percent respectively The 51 4 percent from federal sources included 2,197 0 million dollars total cash reimbursements and 414 0 million dollars in agricultural commodities (Hiemstra, 1983) Federal cash payments and commodity entitlements are specified by legislation based on the number and type of meals served In addition, schools receive bonus commodities not charged against their legislated commodity entitlements In 1982, the value of bonus commodities totaled 340 0 million dollars Bonus commodities totaled 340 0 million dollars Bonus commodities are foods that are in substantial surplus, primarily dairy foods The foods provided to schools by USDA cost less than locally purchased food of the same quality, however, some of these donated foods are reportedly difficult to use in preparing meals and can increase the operating cost of the NSLP due to the high cost of transporting, storing, handling, and processing donated commodities into usable products (Puma and St Pierre, 1983)

The success of the NSLP in meeting its stated objectives relies greatly on keeping the cost of the lunch from rising The charge to the student for the school lunch has been reported to be a strong influence on participation in the NSLP Ottman (1956) concluded that high participation in the NSLP required the charge per lunch be as low as is consistent with good food and service Lunch price was also reported by Akin, Guilkey, Popkin, Bass, and Haines (1981) to significantly reduce the NSLP participation of low income children Keeping the student's payment from rising forces the NSLP to rely greatly on federal funding sources, however, possible budget cuts and rising food and equipment costs due to inflation threaten the adequacy of these sources The continuation of the NSLP requires wiser food purchases, better inventory control, and improved managerial skills (Applebaum, 1982)

Statement of the Problem

The use of commodity foods for the on-site preparation of school foodservice menu items currently being purchased in pre- or partially prepared convenience forms could save money to offset inflationary food costs and help create a more self-supported NSLP (Neill, 1981) On-site grinding of wheat and bread baking has been successfully tried

(Anonymous, 1979) and the concept could be applied to other school foodservice menu items Greater reliance upon uncommitted bonus commodities currently available has great potential in the attempt to control food costs As of May, 1985, Commodity Credit Corporation (CCC) uncommitted stocks of butter, cheese, and nonfat dry milk (NFDM) totaled 163 5, 601 1, and 967 8 million pounds respectively (USDA, 1985) NFDM is, however, one of the commodities many schools report difficulty in using without paying to have it processed into a more usable form (VanEgmond-Pannell, 1981)

Purpose of the Study

The purpose of the study was to develop a soft-serve ice milk mix utilizing USDA bonus commodity NFDM and butter to be mixed and frozen on-site in school foodservice operations The ice milk developed needed to be acceptable to secondary students and within suggested sanitation standards for soft-serve products

Objectives and Hypotheses

The objectives tested were as follows

1 To develop a vanilla soft-serve ice milk mix utilizing USDA commodity nonfat dry milk (NFDM) and USDA commodity butter that can be prepared on-site in school foodservice operations

2 To test the acceptability of the two highest quality soft-serve ice milk mixes in seven junior and senior high schools in Lawton, Oklahoma

3 To have the product meet commercial product standards for total bacterial count and coliform count

The hypotheses tested were as follows

H1 There will be no significant differences among the quality scores of the soft-serve ice milk mixes when descriptively evaluated by a trained taste panel

H2 There will be no significant difference between the acceptability of the soft-serve ice milk mixes when evaluated by secondary students

Assumptions

The following assumptions were made for this study

1 The supply of bonus commodity NFDM and butter will continue to be available to the NSLP

2 Foodservice employees will have time during their respective work shifts to prepare the ice milk mix

3 On-site preparation of the soft-serve ice milk made from bonus commodity NFDM and butter will be less expensive than utilizing a commercially pre-prepared soft-serve ice milk mix

4 All ice cream freezers used in the study will freeze the ice milk mixes in the temperature range of 18 to 22°F (-8 to -5 5°C)

5 The majority of school foodservices participating in the NSLP will have a soft-serve ice cream freezer and are currently serving a commercially prepared soft-serve product

Limitations

In conducting this study, the following limitations were taken into consideration

1 The population was limited to those university students enrolled in one Food Principles class in the fall semester of 1985 and

to those secondary students enrolled in public school in Lawton, Oklahoma in the spring semester of 1986

2 The environmental temperature was not controlled in the unair-conditioned school foodservice cafeterias, changes in environmental temperatures could introduce bias into the acceptability findings

3 The soft-serve ice milk mixes tested were prepared in a university food laboratory that was not equipped with quantity food equipment

Definition of Terms

The major terms used in this study are defined as follows

1 Ice Milk - frozen dairy product containing not less than 2 nor more than 7 percent milkfat, not less than 11 percent nonfat milk solids, and not less than 1 3 pounds total solids per gallon (Code of Federal Regulations, 1984)

2 Ice Cream - frozen dairy product containing not less than 10 percent milkfat and nonfat milk solids, and not less than 1 6 pounds total solids per gallon (Code of Federal Regulations, 1984)

3 Soft-Serve - frozen product consumed when drawn from the ice cream freezer as a flowable semi-solid mass at temperatures between 18 and 22°F (-8 and -5 5°C) (Keeney and Dahle, 1960)

4 Bonus Commodity - primarily dairy foods (milk, butter, cheese) that have been in substantial surplus since 1978 (Hiemstra, 1983)

5 Nonfat Dry Milk (NFDM) - dried skim milk containing not over 5 percent moisture and 1 5 percent milkfat (Rubis, 1974)

6 Butter - the natural fat of milk containing not less than 80 percent milkfat and not more than 16 percent moisture (Rubis, 1974)

7 Nonfat Milk Solids (NFMS) - nonfatty portion of milk including milk sugar, milk proteins, and mineral salts (Keeney and Dahle, 1960)

8 Serum Solids - nonfat milk solids (Keeney and Dahle, 1960)

The typical factors for scoring dairy products are defined as follows

9 Color - visual perception or appearance readily associated with the flavor (Arbuckle, 1972)

10 Flavor - blend of taste, smell, and temperature sensations evolved in the mouth (Amerine, Pangborn, and Roessler, 1965)

11 Texture - the way the product handles and feels in the mouth (Szczesniak, 1963)

12 Body - consistency of the product and the way the product behaves when it begins to warm and melt (Charley, 1970)

Format of Dissertation

Chapter III was written according to the Guidelines for Authors of the School Food Service Research Review Chapter IV followed the Guide for Authors, Journal of the American Dietetic Association

CHAPTER II

REVIEW OF LITERATURE

Characteristics of Ice Milk

Ice milk is a frozen dairy food produced by freezing, with continuous agitation, a combination of dairy ingredients, sweeteners, water, and flavoring, with or without eggs and/or stabilizers or emulsifiers (Arbuckle, 1972) Ice milk differs from ice cream in the composition of the mix Expressed as a percentage of its ingredients, ice milk contains not less than 2 percent nor more than 7 percent butterfat, and not less than 11 percent nonfat milk solids (NFMS) (Code of Federal Regulations, 1984) Soft-serve ice milk differs from hardened ice milk and ice cream as it has only a one-step freezing process Soft-serve products are consumed when drawn from a batch-type ice cream freezer as a flowable semi-frozen mass at temperatures between 18 and 22°F (-8 and -5 5°C) (Keeney and Dahle, 1960) Hardened products are frozen solid during a second freezing period in a cold-storage room at 0°F (-18°C)

Like ice cream, ice milk is evaluated by the organoleptic properties of color, flavor, texture, and body (Collins, 1980) A high quality soft-serve ice milk possesses the following characteristics

Color

The color needs to be attractive, evenly distributed, and characteristic of the flavor An ideal vanilla flavored product is an off-yellow, the color of cream produced in spring and early summer due to the high content of carotene in the grass at these times (Sommer, 1951) Maintaining uniform color throughout the year usually requires the addition of imitation colorings

Flavor

Flavor is identifiable by taste, color, and pieces of ingredients, (i e , fruits, nuts, or chocolate) dispersed in the product High quality flavor should be pleasing with sufficient flavoring to yield a distinctive, full-flavor to the product (Collins, 1980) The flavor of vanilla ice milk depends, to a great extent, on the quality of its dairy ingredients Milk flavor is subject to the individuality of the cow, the period of lactation, the feed, the barn atmosphere, bacterial action, and/or chemical changes in the milk (Walstra and Jenness, 1984) Ice milk should also be sweet with the degree of desirable sweetness varying considerably between consumers Sommer (1951) suggested that children and younger people prefer a sweeter product than do older individuals Colder temperature sensations characteristic of ice milk compared to ice cream are attributed to the lower percentages of butterfat in ice milk

Texture

Texture characteristics include a smooth and creamy feel in the mouth with no detectable granules on the palate Tactile sensations of thickness and richness also indicate a quality product (Keeney and Kroger, 1974) High quality texture is reported to be due to uniformly dispersed, small, angular-shaped ice crystals, jagged tapering air cell configurations, (Reid and Hales, 1934), and the sensation of smoothness imparted by the lubricating properties of butterfat (Cole and Boulware, 1940)

Body

A desirable body needs to be dry and stiff Dryness is associated with a low gloss and a melt-resistant product (Keeney and Josephson, 1958) Since soft-serve products are not hardened, stiffness implies a product that will stand up properly in the container and retain its shape and consistency until eaten (Knightly, 1963) High quality body depends on some butterfat agglomeration (Sherman, 1965), low draw temperatures (Keeney and Dahle, 1960), fine, uniform air cell structure (Keeney and Josephson, 1958), and use of the proper emulsifier and/or stabilizer (Bassett, 1969)

Physical Structure of Ice Milk

The quality characteristics of ice milk are attributed to the physical and chemical functions of the ingredients combined with the freezing process Collectively the ingredients and the freezing process produce a complicated foam of air bubbles trapped in a continuous liquid phase which represents a partially frozen emulsion (King, 1950) Water, frozen and unfrozen, functions as the continuous phase Ice crystals are embedded in the frozen continuous phase while the unfrozen continuous phase contains emulsified fat globules, collodial dispersions of milk proteins and insoluble salts, and solutions of sucrose, lactose, and soluble salts (Valaer and Arbuckle, 1961) The structural elements of ice crystals, air cells, and unfrozen materials are separated by three interfaces The air-milk plasma interface, covered by a thin absorptive film or lamellae, the fat-milk plasma interface, covered by a protein-emulsifier film, and the ice-milk plasma interface (King, 1950)

During freezing, continuous agitation incorporates air producing a foam Slow freezer speeds with extended agitation periods favor the dispersion of very small, uniformly distributed air cells which promote a smooth texture and stiff body The foaming of the mix is due chiefly to milk proteins which are absorbed by the lamellae and stabilize the entrapped air (Atherton and Newlander, 1977) The mix increases in volume due to foam formation and the expansion of water as it freezes, this increase in volume during freezing is referred to as overrun It is expressed in percentage as follows

$$\%\text{ overrun} = \frac{\text{weight of mix - weight of ice milk}}{\text{weight of ice milk}} \times 100$$

where the weight of each product is the weight of the same unit of volume (Keeney and Kroger, 1974) Ice milk of insufficient or excessive overrun is soggy and heavy or snowy or fluffy respectively Soft-serve ice milk is dispensed at overruns of 30-50 percent (Kenney and Dahle, 1960)

The temperature of the ice milk mix in the freezer is quickly lowered to 21-23°F (-6 - -5°C) to enhance the formation of small ice crystals necessary for smooth texture and stiff body As small ice crystals separate from the water of the mix, the viscosity of the unfrozen water increases Ice crystals remain small because water molecules, slowed by the increase in viscosity, are unable to unite with existing crystal nuclei but instead form new ice crystals The separation of pure ice crystals from the mix increases the concentration of the remaining unfrozen mix and, consequently, decreases the freezing temperature The continuous decrease in the freezing temperature prevents all of the water from freezing In soft-serve products, approximately one-half of the water in the mix is frozen (Lampert, 1970)

Functions of Ice Milk Ingredients

Basic ingredients in ice milk include butterfat, NFMS, sweetener, stabilizer and/or emulsifier, and flavoring

Butterfat

The butterfat globules, covered by a protein-emulsifier film at the fat-milk plasma interface, are dispersed in the unfrozen phase of the mix as single globules and/or aggregates of globules Chain-like arrangements of globules are found around the air cells and throughout the unfrozen phase Studies by Cremer (1954) indicated that the chain-like arrangements of butterfat on the surface of air cells are more easily tasted than those dispersed in the unfrozen phase, and yield a subtle creamy flavor Fresh sweet cream is the preferred source of butterfat as it imparts the best flavor, however, sweet, unsalted butter may be used (Sommer, 1951) Improperly stored butter develops flavor defects due to oxidation, however, Price and Whitaker (1931) studied the flavor of butter frozen up to eight months and detected no odor or taste of oxidation in ice cream made from the frozen butter Acting as a mechanical barrier, butterfat contributes to the smooth texture by preventing the growth of ice crystals In addition, smoothness depends on the total air cell surface area and the amount of fat surrounding the air cells (Cremer, 1954) An optimum ratio of fat to air appears to impart a lubricating effect and the sensations of thickness and richness. Sherman (1965) reported smooth texture to result from initial small butterfat globules in the mix and the coagulation of solidified butterfat particles into small aggregates distributed throughout the unfrozen phase between the air cells and ice crystals. In the ice milk mix, butterfat globules are fluid, sticky spheres that require emulsifiers to keep the globules separated and link the surface of the butterfat with the water (Bassett, 1969). During freezing, applied pressure ruptures the protein-emulsifier film around some of the globules, adjacent de-emulsified globules aggregate throughout the unfrozen phase between the air cells and ice crystals (Shama and Sherman, 1966). The controlled formation of small butterfat aggregates enhances air retention and results in a dry stiff body (Knightly, 1963), while uncontrolled butterfat de-emulsification, or churning, results in clumps of butterfat large enough to be detected in the mouth. The rate of agglomeration and churning is a function primarily of the degree of agitation (Knightly, 1959), however, Keeney and Josephson (1958) suggested that polyoxyethylene emulsifiers enhance butter agglomeration by promoting controlled fat de-emulsification. Churning is a more serious problem in soft-serve versus hardened products as soft-serve mixes may be agitated in the batch type freezer for periods of 12 hours or longer (Knightly, 1963).

Nonfat Milk Solids (NFMS)

The nonfat solids of milk, referred to as skim milk solids and serum solids, include lactose, proteins, and minerals salts (Arbuckle, 1972). Fresh skim milk and fresh spray process nonfat dry milk (NFDM) are the most frequently used sources of NFMS The flavor these milks impart to ice milk depends on any unpalatable odors or flavors the milk may absorb from the feed or may result from chemical, microbial, and/or enzymatic reactions during the manufacture or storage of the milk Fresh skim milk produced under ideal conditions has a bland (low acid), slightly sweet, clean flavor Low fat milks taste somewhat flat in comparison to milks with higher percentages of fat which have fuller flavors The flavor of dried skim milk depends upon the quality of the raw material from which it is made, the process of manufacturing, the conditions of storage, and the age of the product (Price and Whitaker, 1931) A quality NFDM powder should be of fine flavor, light in color, free from darkened particles, fluffy, and easily soluble (Arbuckle, 1972). Poor quality NFDM is characterized by an old ingredient flavor (van der Zant and Moore, 1954) and often produces a cooked or "serum solids" off-flavor in ice cream (Arbuckle, 1972) A "powdery" flavor has been reported due to NFDM powders that do not dissolve well (Piper, 1955) Hedrick, Armitage, and Stine, (1964) studied the flavor effect of pasteurization temperatures on dried milk and concluded that milks pasteurized by high-heat (185°F (85°C) for 20 minutes) produced ice milk mixes with more pronounced "cooked" flavors than mixes made using low-heat (143°F (61 5°C) for 30 minutes) pasteurization The differences, however, were slight and, in vanilla ice cream, would probably not be noticeable to the average consumer Williams (1929) reported that ice cream made from NFDM heated to 181 4°F (83°C) produced a better flavor than NFDM heated to 145 4°F (63°C) Flavor differences are also reported between ice creams made from different types of dried skim milk When comparing drum dried to spray dried, 66 3 percent of sensory evaluators preferred the flavor of ice cream made from spray dried NFDM (Williams and Hall, 1931) Price and Whitaker (1931) compared spray, flake, vacuum-roll, and atmospheric-roll dried skim milk and reported the best flavor in ice cream made from spray dried milks stored for less than 3 months at temperatures of 46 and 0°F (8 and -18°C) A stale flavor may develop in NFDM during storage due to moisture absorption Moisture contents of 3 percent or below will limit the production of stale flavors, however, NFDM is hygroscopic and will absorb moisture from the atmosphere, consequently, dry storage is necessary (Sommer, 1951)

NFMS improve ice milk texture by favoring the formation of small ice crystals and air cells Formation of small ice crystals is attributed to the hydrophylic properties of milk proteins The smooth texture is partially due to the size and distance between ice crystals Milk proteins' affinity for water reduces the amount of water converted into ice and hydrated protein particles mechanically obstruct ice crystal growth by deflecting water molecules from uniting with existing crystals so more numerous smaller crystals are formed (Little, 1948) As the concentration of NFMS in the unfrozen phase increases, the freezing point lowers, thus preventing all of the water from freezing The greater the amount of unfrozen phase, the greater the distance between ice crystals (Arbuckle, 1940) Smoothness is also attributed to air cell size and distribution which is affected by the freezing mechanism, the viscosity of the mix, and the strength of the lamellae surrounding the air cells As the mix is agitated during freezing, air is incorporated and sub-divided into small air cells Mix vicosity increases due to the collodial properties of milk proteins and due to the increased concentration of NFMS in the unfrozen phase of the product The viscosity of the mix is responsible for the retention of the air cells The strength of the lamellae affects ice milk texture by resisting air cell deformation (Sherman, 1965) and the resultant loss of air as the cells run together during agitation and freezing As the amount of air incorporation or overrun increases, compression of the foam causes the form of the foam to change (King, 1950) from spherical to honeycomb-like to poylhedric With increased compression, the lamellae become very thin and are increasingly susceptible to rupture or to piercing by ice crystals (Dahlberg, 1925) High levels of total solids strengthen the protein-emulsifier film surrounding butterfat globules, and thereby lessen the churning of butterfat (Kloser and Keeney, 1959) During freezing, applied pressure is sufficient to rupture the film around some of the globules, consequently, the ratio of NFMS to fat is one factor in controlled fat de-emulsification Mixes with total solid concentrations less than 85 percent of that of the fat are particularly unstable and susceptible to churning (Knightly, 1959) High levels of NFMS also increase mix viscosity and strengthen the lamellae surrounding the air cells Strong lamellae enable the mix to retain a given amount of air in the form of small cells (Sommer, 1932) The amount of air incorporated or the percentage of overrun is not reported to be affected by the level of NFMS (Lucas and Roberts, 1927), but to be the result of the amount and speed of agitation

Sweetener

The sweetness of ice milk results from sucrose, corn sweetener, and, to a slight degree, from lactose Sucrose is always used in ice milk and most products utilize corn sweetener at levels of 4-6 percent solids (Keeney and Dahle, 1960) Sugar increases the acceptance of ice milk by making it sweeter In addition, sugar lowers the freezing point of the mix which increases the viscosity of the unfrozen phase Lower freezing temperatures and increased viscosity promote smoothness in the frozen product by enhancing the formation of small ice crystals and increasing distances between ice crystals Lower freezing temperatures also require a lower drawing temperature in order to obtain a dry stiff product, soft-serve mixes usually contain less sugar than mixes to be hardened (Kloser and Keeney, 1959)

Emulsifier/Stabilizer

Most ice milk mixes contain an emulsifier, or surfactant, in order to produce an emulsion of the immiscible liquids As esters of long chain fatty acids and alcohol (Potter and Williams, 1950), emulsifiers are both hydrophilic and lipophilic Oriented at the fat-milk serum interface, emulsifiers permit a fine dispersion of butterfat in the mix by reducing interfacial tension Consequently, butterfat agglomeration is controlled and a dry, stiff body results Two types of emulsifiers are approved by the Food and Drug Administration (FDA) for use in ice milk and ice cream Fat soluble emulsifiers, referred to as "monos", are mixtures of mono- and diglycerides derived from hydrogenated vegetable and animal fats Water soluble polysorbate emulsifiers, referred to as "polys" are formed from dehydrated sorbitol esterified with a fatty acid to produce compounds known as Spans (Kloser and Keeney, 1959) Reacting Spans with ethylene oxide produces polyoxyethylene derivatives referred to as Tweens Polyoxyethylene derivatives of sorbitan tristearate and sorbitan monooleate are commonly known as Polysorbate or Tween 65 and 80 respectively (Bassett, 1969) The monos primary function is to improve the whipping ability of the ice milk mix by reducing the fat-milk serum interfacial tension which stabilizes the fat dispersion and retards butterfat agglomeration (Arbuckle, 1972) A dry, stiff body is reportedly due to the polys' ability to promote fat de-emulsification, probably by impairing the cohesion of the protein-emulsifier film surrounding butterfat globules (Mulder and Walstra, 1974) During freezing and agitation, the butterfat globules begin to clump together in agglomerates, continued agitation causes the butterfat to coalesce into visible and tactile particles When the globules have agglomerated but before they coalesce, the ice milk possess the maximum dryness and stiffness due to the mechanical viscosity imparted by the butterfat agglomerates In soft-serve ice milk, approximately 0 05 percent poly and up to 0 2 percent mono is recommended to control butterfat agglomeration due to extended agitation periods (Bassett, 1969) Legal maximums of emulsifiers in ice cream and ice milk are 0 10 percent poly plus 0 2 percent mono

Known as hydrophilic colloids, stabilizers are thickening agents that promote ice milk mix viscosity which improves aeration and body, restricts ice crystal growth during storage, and controls the rate of melt-down (Cottrell, Pass, and Phillips, 1980) Stabilizers are polysaccharides obtained from various sources, including seaweed extracts, seed gums, tree gum exudates, and chemically modified celluloses (Cottrell, Pass, and Phillips, 1979) The major stabilizers used in ice milk are sodium carboxymethylcellulose (CMC), locust bean gum, guar gum, carrageenan, and sodium alginate (Bassett, 1969)

In addition to using emulsifiers and/or stabilizers in the promotion of a dry, stiff body, soft-serve mixes may contain certain salts as drying agents Soft-serve products are more prone to the churning of butterfat than hardened products due to extended periods of agitation Frazeur (1959) reported that the precautions of proper freezer temperatures, correct mix temperature as the mix enters the freezer, and the use of emulsifiers may not prevent butterfat churning Salts employed as drying agents include sodium citrate, disodium phosphate, tetrasodium pyrophosphate, sodium hexometaphosphate, and calcium sulfate Arbuckle (1952) reported that the addition of 0 08 to 0 20 percent calcium sulfate produced a dry, stiff product with a reduced rate of melting The salts are reported to function by retarding butterfat churning due to their ability to increase the electrostatic charge on the surface of butterfat globules and/or to stabilize proteins in the butterfat globule membrane

Flavoring

Flavor in an ice milk mix may come from the plain mix and from an added flavoring material Over 75 percent of ice cream is flavored with vanilla, chocolate, or strawberry Vanilla accounts for over 50 percent of the total production (Keeney and Dahle, 1960) Extracts are the most popular form of vanilla flavoring, however, due to price considerations, most vanilla flavorings are combinations of natural vanilla extract and imitation vanilla flavors from ethyl vanillin, or other aromatics A good quality vanilla flavoring complements the natural milk flavor Imitation vanillas often do not duplicate a true vanilla flavor or odor and may strongly dominate the ice milk Sampling studies by Pierce, Combs, and Borst (1924) reported that judges were unable, however, to identify true and imitation vanilla flavors in ice cream samples

Defects in Ice Milk

The quality of ice milk is judged on the basis of its color, flavor, texture, body, and bacterial count If the product deviates from the commonly recognized standards, it is said to be defective

Color

A natural color is desirable in ice milk An unnatural color may be insufficient or pale, excessive or intense, or not a true shade for the flavor (Arbuckle, 1972) Defective vanilla colors include chalky, pale, dull and grayish, unevenly colored, or colored to an unnatural shade (Sommer, 1932) King (1950) reported a "whiter" color in products with finely dispersed ice crystals and air cells than products with course textures

Flavor

Flavor defects may be due to excessive or deficient sweetness, excessive, deficient, or atypical flavorings, and poor quality dairy products Lack of sweetness produces a flat taste while excessive sweetness overshadows desirable flavors Vanilla flavoring defects most frequently occur from the use of imitation vanilla extract which imparts a pronounced coumarin flavor in vanilla flavored ice cream (Sommer, 1951) The flavor of the dairy products depends on any unpalatable odors or flavors absorbed by the feed or that may result from chemical, microbial, and/or enzymatic reactions during manufacture or storage

Feed off-flavors may be inhaled or digested by the cow and transferred to the milk In addition, a "cowy" flavor may occur from the transfer of feed or stable taints or from ketosis which produces increased concentrations of acetone in the milk (Salstra and Jenness, 1984) Chemically induced off-flavors include defects from oxidation, storage, heat, Maillard reactions, and light exposure. Oxidation of milks' lipid fraction produces a variety of flavor defects Flavors described as oily, cardboard, tallowy, and metallic occur as the concentration of carbonyl compounds increase from the oxidation of unsaturated fatty acids (Forss, Pont, and Stark, 1955) Storage or stale flavors develop in NFDM due to high moisture contents and high storage temperatures High quality NFDM has a moisture content of 3 percent or below (Sommer, 1951), however, NFDM is hygroscopic and, with improper storage, the absorbed moisture content increases NFDM stored at improper temperatures (110°F (43°C) or higher) is reported to develop a coconut flavor (Walstra and Jenness, 1984) Heat treatment of milk during high or ultra-high pasteurization, 180°F (82°C) for 10 seconds and 285°F (140 5°C) for 1 second respectively, produces the tactual flavor defects of chalky, rough, powdery, or astringent (Patton and Josephson, 1952) Milk pasteurized at low temperatures (165°F (74°C) for 10 seconds) is free of heat-induced flavors Milks heated at higher temperatures impart a cooked flavor due to the production of free sulfhydryls from the breakage of disulfide bonds NFDM produced by high heat drying (185°F (85°C) for 20 minutes) contains a greater cooked flavor than low heat processed NFDM (143°F (62 5°C) for 30 minutes) (Hedrick et al, 1964) Off-flavors may develop due to Maillard reactions during storage, heating, and drying of milk Characteristic flavors include caramel, malty, and roasted A typical Maillard reaction flavor in dried milk is a gluey-stale flavor (Walstra and Jenness, 1984) Excessive exposure to light during fluid milk storage produces a sunlight flavor due to the photolysis of methionine in the presence of riboflavin (Patton, 1954) The sunlight flavor is described as burnt or cabbagey (Jenness and Patton, 1959) Off-flavors produced by the growth of microorganisms or the action of bacterial or milk enzymes include unclean, fruity, malty, phenolic, bitter, and rancid

Texture

Ice milk texture is directly related to the size, shape, number, and arrangement of the air cells, ice crystals, lactose crystals and fat clumps, when these structures are detectable in the mouth, the texture is defective Common texture defects are described as coarse or icy, snowy or fluffy, buttery, and sandy (Sommer, 1932) A coarse or icy texture indicates the presence of large ice crystals or air cells. Open textures due to the incorporation of excessive air are referred to as snowy or fluffy Ice milk is buttery when clumps of butterfat, due to churning, are easily seen or detected on the palate Lactose crystallization produces a sandy sensation that remains as the product melts in the mouth Lampert (1970) indicated that mixes with NFMS concentrations of 11 percent or higher were prone to lactose crystallization, however, storage time and temperature are reported to be additional factors (Sommer, 1932) When the product is consumed within 5-7 days and stored in reasonably constant temperatures, mixes with 11 percent of NFMS do not become sandy Keeney and Kroger, (1974) indicated more frequent sandiness in products stored at temperatures above 0°F (-18°C) and

Nickerson (1962) reported higher percentages of lactose crystallization in mixes drawn from the freezer at low (23°F (-5°C)) draw temperatures than mixes drawn at higher (25-26°F (-4 - -3 5°C)) temperatures

Body

Characteristic body defects include crumbly, soggy, gummy, and weak A crumbly or brittle body lacks cohesion and pulls apart easily, it is associated with low total solids, insufficient stabilizer, excessive overrun, or large air cells (Arbuckle, 1972) A dense consistency that appears somewhat wet is described as soggy or heavy which results from low overrun especially in mixes with high total solids Sommer (1932) considered a product with 38 percent total solids and an overrun below 80 percent to be soggy A product with a gummy or pasty body appears as a doughy mass upon serving and resists melting Excessive concentrations of stabilizers produce this defect A weak or watery body results from low total solids and insufficient stabilizer The product lacks firmness or chewiness and melts quickly

Bacterial Count

Suggested bacteriological standards for soft-serve ice milk state that the finished product shall have a bacterial plate count not to exceed 50,000/g and a coliform count not to exceed 10/g (Weckel, 1966) Satisfying these standards requires care in the selection of raw materials, pasteurization of the mix, storage of the mix and sanitation of equipment (Ryan and Gough, 1982) In selecting NFDM for ice milk mixes, bacterial counts are specified for Extra and Standard Grades based on 10 g of powder suspended in 100 cc of sterile water The bacterial count must be less than 30,000 and 100,000/g for Extra and Standard Grades respectively (Sommer, 1951) Due to sugar's protective effect on the destruction of microorganisms, a minimum of 155°F (68°) for 30 minutes or 175°F (79°C) for 25 seconds is advised for pasteurization treatments with ice cream mixes Other temperature-time combinations that are reported equal to or in excess of the above minimal include 176°F (80°C) for 22 seconds and 185°F (85°C) for 6 1 seconds Thermophilic organisms may produce a high plate count in mixes held at too high temperatures for extended times during cooling or storage (Sommer, 1951) The mix should be stored at 45°F (7°C) or below until the mix enters the freezer-dispenser (Weckle, 1966) Van der Zant and Moore, (1955) reported considerable increases in bacterial counts in mixes stored above 41°F (5°C) and considerable increases in coliform counts in mixes stored at 48°F (9°C). Storing mixes between 41 and 46 4°F (5 and 8°C) resulted in small increases in total count and coliform after two days Adequate cleaning and sanitizing of equipment are essential in avoiding recontamination of a mix with initially low bacterial counts Equipment used in storing and freezing should be dismantled, washed, rinsed, and left to air dry after each day's use and sanitized with solutions containing not less than 100 ppm available chlorine before subsequent use (Weckle, 1966) Data from 71 samples collected from soft-serve retail stores revealed 62 5 to 92 6 percent of all mix samples contained $\leq$ 50,000/ml total bacteria and 69 7 to 76 5 percent contained $\leq$ 10/ml coliform (Martin, Roberts, and Sheuring, 1968) Once frozen, however, only 36 to 50 percent and 44 9 to 55 8 percent met the standards for total bacteria and coliform respectively Ryan and Gough, (1982) tested soft-serve samples from fast food chains, local retail outlets, and institutional cafeterias and found significant ($P \leq .01$) differences in the distribution of total bacteria and coliform counts between mixes and frozen products. Of 252 mix samples, 10.7 percent contained > 50,000/g total bacteria and 7.5 contained > 10/g coliform. The results from 817 frozen samples showed 38.5 and 51.2 percent exceeded the standards for total bacteria and coliform respectively.

Foley and Sheuring (1966) concluded that agitation during freezing in a soft-serve ice cream freezer causes death to microbial cells due to the abrasive action of rapidly moving extracellular ice crystals. Significant ($P \leq .01$) reductions in _Escherichia coli_, _Saccharomyces lactis_, and _Pseudomonas fluorescens_ occurred between the fifth and eighth minute of freezing (Foley and Sheuring, 1965).

Summary

Soft-serve ice milk is a frozen dairy product that is consumed when drawn from the ice cream freezer without hardening. Characteristics of high quality vanilla soft-serve ice milk satisfy the following standards: off-yellow color, pleasant sweet vanilla flavor, smooth and creamy texture, body stiff enough to retain shape until eaten, and a bacterial and coliform count $\leq$ 50,000/g and $\leq$ 10/g respectively. The quality characteristics are attributed to the physical and chemical functions of the ice milk ingredients combined with the freezing process. Basic ingredients in ice milk include: 2-7 percent butterfat, not less than 11 percent NFMS, sweetener, stabilizer and/or emulsifier, flavoring, and water. The production of high quality soft-serve ice milk depends on the selection of high quality ingredients, especially the dairy ingredients, proper storage of the mix, and adequate sanitation of the ice cream freezer.

CHAPTER III

PREPARATION AND SENSORY EVALUATION OF BONUS COMMODITY SOFT-SERVE ICE MILK

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Abstract

Four vanilla soft-serve ice milk mixes utilizing USDA commodity nonfat dry milk (NFDM) and butter were developed for on-site preparation in the National School Lunch Program (NSLP) The mixes differed in the percentages of NFDM and butter and contained equal amounts of granulated sugar, imitation vanilla, and a combination emulsifier/stabilizer A trained taste panel descriptively evaluated the mixes for color, sweetness, flavor, freshness, texture, and body using an equal interval scorecard One mix scored significantly different ($P \leq$ 01) than all others, no significant differences were found among the remaining three mixes

Introduction

A purpose of the National School Lunch Program is to safeguard the health and well being of the Nation's children and to encourage the domestic consumption of agricultural commodities Schools receive entitlement commodities based on the number and type of meals served while bonus commodities of cheese, butter, and NFDM are provided freely Of the commodity foods received, schools frequently report difficulty in incorporating NFDM into menu items without paying to have the NFDM processed into a more usable product (1)

Dried skim milk and butter can be successfully used as the sole sources of nonfat milk solids (NFMS) and butterfat in ice cream or ice milk mixes (2) In formulating the mix, the quality of ingredients is more important than the source of the ingredients and, when properly handled, high grade butterfat and NFDM combined with sugar, stabilizer, flavor, and possibly color can produce a good product (3) Arbuckle (2) recommends the use of Extra Grade NFDM in ice cream production Requirements for Extra Grade specify a moisture content of 4 percent and that the dry and reliquified products be entirely free from storage or scorched flavor or odor In addition, Extra Grade powders have solubility indices of 1 25, 2 0, and 15 0 for spray, vacuum-roll, and atmospheric-roll dried milks respectively Sweet unsalted butter is preferred in ice cream and should be very mild in flavor or almost flavorless (4)

The purpose of the study was to develop a soft-serve ice milk mix utilizing bonus commodity NFDM and butter to be mixed and frozen on-site in school foodservice operations and served in the NSLP

Methods

Research Design In order to evaluate the bonus commodity soft-serve ice milk when prepared with high and low levels of NFDM and butter, four vanilla mixes (Table 1) were developed from a series of preliminary experiments (Appendix A) The four frozen mixes were descriptively evaluated by a sensory panel to determine the two best quality mixes, two mixes of highest quality were selected to be evaluated for acceptability by secondary students in another study (CHAPTER IV) In each soft-serve ice milk mix, the percentages of sugar, imitation vanilla, and emulsifier/stabilizer combination were held constant The percentages of bonus commodity NFDM and butter in each mix were the manipulated independent variables Data were collected in a random balanced incomplete block design with replications (5) The ice cream freezer used in the study was designed to freeze two mixes simultaneously, consequently, the ice milk mixes were randomly assigned to the tasting sessions in combinations of twos To assess panel reliability, each combination was evaluated twice, reversing the serving position of each mix within each combination

Ice Milk Mixture Preparation USDA bonus commodity NFDM and butter, donated to the study through the USDA Regional Office in Dallas, Texas, provided the sole sources of NFMS and butterfat in each mix The NFDM was spray process Extra Grade produced between March and June of 1984, the butter was salted and produced in March and June of 1985 The NFDM was packaged in 50 pound paper bags with plastic liners and was stored tightly closed and away from light One pound packages of butter were stored frozen in a home size refrigerator/freezer at 18°F (-8°C) The mixes were sweetened with granulated sugar (sucrose) and flavored with imitation vanilla flavoring Southern Special Emulsifier Combination, donated to the study by Go Products of San Antonio, Texas, was used as the emulsifier/stabilizer Ingredients selected for use are permissible according to the Federal Standards for Frozen Desserts (6) One gallon of each mix to be evaluated was prepared the afternoon of the day before the tasting session. The dry ingredients and butter were measured by weight, liquid ingredients were measured by volume. The water, frozen butter, and emulsifier/stabilizer combination were combined and heated to 185°F (85°C) in order to dissolve the locust bean gum component of the emulsifier/stabilizer (7). The hot mixture was stirred with a wire whisk and removed from the heat once the above specified temperature was reached. The NFDM and sugar were combined in order to minimize lumping of the NFDM when added to the liquid ingredients (8). The dry ingredients were added to the liquid ingredients and mixed with a wire whisk until no lumps of NFDM remained. The vanilla was then added and thoroughly blended into the mix. The prepared ice milk mixes were cooled to 40°F (4°C) in identical 2-gallon containers that were placed in identical styrofoam ice chests. Each 2 gallon container was surrounded with a mixture of three quarts of ice cubes and one quart of water in order to bring the depth of the ice and water equal to the depth of the ice milk mix in the container. The cooled mixtures were removed from the ice chests, the containers were covered with tight fitting lids, and refrigerated at 40°F (4°C) overnight.

Freezing Procedure. The mixes were frozen in a model #733 Taylor soft-serve ice cream freezer loaned to the study by Jeff Thomas Enterprises, Oklanoma City, Oklahoma. Model #733 is a continuous console model with twin heads allowing two mixes to be frozen and dispensed simultaneously. For each tasting session, the ice cream freezer was assembled and sanitized for two minutes with a 78°F (25.5°C) solution containing 100 ppm available chlorine. Two ice milk mixes, at 40°F (4°C), were added to the sanitized freezing chambers and agitated until frozen, approximately 12-15 minutes. The ice milk was dispensed between 18 and 22°F (-8 and -5 5°C) After freezing, the percentage of overrun for the soft-serve mixes was calculated by the formula reported by Keeney and Kroger (9) At the completion of each tasting session, any remaining ice milk was drawn-off and discarded The ice cream freezer was thoroughly rinsed with water, disassembled, and all parts were washed with a detergent solution, rinsed, covered with kitchen towels, and allowed to air dry

Subjects In the fall of 1985, a university Food Principles class of nine students was used as a convenience sample Students were accepted as panel members by a triangle test screening process (10) All nine students correctly identified the odd sample in nine or more of 14 triangle tests ($P \leq 05$) (11) and were accepted as taste panel members Prior to data collection, one taste panel member moved out of state, leaving a taste panel of eight members All panelists were female, predominately in their early 20's except two who were in their 30's and 40's

The triangle tests were conducted using a basic vanilla ice milk formula (12) (Table 2), frozen in 4-quart electric home-style ice cream freezers The ice milk was evaluated immediately after freezing, without additional hardening, in order to approximate a soft-serve product The basic formula was modified (Table 2) to create three-fold differences in the sensory property being tested in order to eliminate those individuals who could not detect large differences in the properties (10) Triangle screening sessions were conducted on seven consecutive Mondays, Wednesdays, and Fridays Two triangle tests were conducted per screening session for a total of 14 tests Each sensory property was evaluated twice by each potential panelist In each test, the basic formula comprised the two matching samples and the odd sample was randomly selected from the modified formulas During the triangle screening sessions, potential panelists were seated in pairs at tables, 4-feet in diameter, separated from view of each other by white, folding cardboard screens Samples were served in 3 5-ounce white paper cups and stainless steel teaspoons were used for tasting Each potential panelist was requested to rinse her mouth with distilled water between samples Triangle test results were recorded on the Triangle Test for Difference form (10) (Appendix B).

Taste Panel Training Taste panel members were trained to recognize and to quantify the desirable sensory properties of soft-serve ice milk during four training sessions During each session, the researcher attempted to demonstrate one of the study's sensory properties by using a commercial vanilla soft-serve ice milk mix (Appendix C) as a standard product compared to one of two ice milk mixes developed by Arbuckle (2) (Appendix C) Arbuckle's two mixes were alternated between the training sessions, all ice milk mixes were frozen in the Taylor #733 ice cream freezer Taste panel members sampled two soft-serve ice milk mixes during each training session, the standard and one of Arbuckle's mixtures In order to secure agreement on the meaning of descriptive terms, taste panel members were acquainted with the definition and related desirable and undesirable characteristics of each sensory property by displaying this information (Appendix D) on an overhead projection during the entire training session Panel members were also introduced to the measurement instrument to be used for descriptively evaluating the study's soft-serve ice milk mixes and used the instrument to evaluate the training session mixes

Taste Panel Evaluation The trained taste panel descriptively evaluated the four soft-serve ice milk mixes in combinations of twos with all possible combinations during the first six tasting sessions During the second six tasting sessions, the combinations were retested, reversing the testing position of each combination (13) Each panelist tasted the same combination during each of the 12 tasting sessions, the samples were coded with a circle or a square The tasting sessions were conducted on consecutive Tuesdays and Thursdays from 12 00 to 12 30 p m During the tasting sessions, panelists followed the same procedures used during the triangle testing sessions

Data Collection The quality of the sensory properties of the soft-serve ice milk mixes was measured by means of an equal interval scorecard (Appendix B) developed by Stone, Sidel, Oliver, Woolsey, and Singleton (14) The scorecard was modified to include the following sensory properties identified (15) as being typical factors for scoring dairy products color, sweetness, flavoring, freshness, texture, and body Descriptive terminology used on the scorecard was adopted from the Ice Cream Scorecard used in the Intercollegiate Dairy Products Evaluation Contest sponsored by the American Dairy Products Association and the Dairy and Food Industries Supply Association Sensory properties were listed on the scorecard in the sequential order that they were encountered by the taste panel members (15) Taste panel members rated each sensory property by placing a verticle line at the point on the scorecard that best reflected the magnitude of the panelists' perceived intensity of that property Responses on the scorecards were converted to three-digit numbers by use of a template marked in tenths of an inch (14) The overall quality score for each mix was calculated as the total of all six sensory property means Personal preferences of the taste panel members between each pair of soft-serve ice milk mixes were recorded on the Ice Milk Evaluation form developed for this study (Appendix B) Internal validity of the taste panel was assessed by comparing the taste panelists' ranked overall quality scores for each ice milk to the ranking of their personal preferences

Data Analysis. Taste panelists' sensory evaluation scores were analyzed by analysis of variance Tests for significant differences among the soft-serve ice milk scores were done by Duncan's multiple range tests (16) Tests for significant differences among panelists' personal preferences were done by Chi square. All hypotheses were tested for significance at the 5 percent ($P \leq 05$) level

Results

Percentage of Overrun All four ice milk mixes dispensed at overruns between 30 and 46 percent (Table 3) The highest overruns were found in mixes two and four which contained lower percentages of butter than mixes one and three However, they were not significantly higher ($P > 05$) than the mixes with the higher content of butter

Taste Panel Reliability and Validity A significant difference ($P \leq 001$) was found between the two tasting sessions for overall quality scores for mix one (Table 4) No significant differences were found between the tasting session for overall quality scores for mixes two, three, and four In addition, no significant difference was found between the tasting session means of the overall mean quality scores

Descriptive Evaluation Mean scores for the sensory properties of the four ice milk mixes revealed no significant differences among any of the mixes when evaluated for color, sweetness, freshness, flavor, and texture (Table 5) Mix two scored significantly different ($P \leq .001$) for body than the other mixes. Panelists reported the body of mix two to be "watery" (Table 6) In comparing the overall quality score for each mix (Table 7), no significant differences were found among the scores of mixes one, three, and four, however, mix two scored significantly different from the other mixes Mix two scored lower than mixes one, three, and four

Internal Validity Significant ($P \leq .05$) differences were found among the panelists' personal preferences for the ice milk mixes (Table 8) Ranked in order of personal preferences, panelists preferred mixes one, three, four, and two Ranked in order of overall quality scores (Table 7), panelists scored mix one the highest, followed by four, three, and two

Discussion

Percentage of Overrun All four ice milk mixes dispensed at overruns between 30 and 50 percent, the usual percentage found in high quality soft-serve ice milk (17) The percentage of overrun is not reported to be affected by the viscosity of the mix (2) nor the level of NFMS (18) but is the result of the amount and speed of agitation The degree of agitation affects the rate of fat agglomeration (19), and, as fat globules aggregate, the lamellae surrounding the air cells weakens and, consequently, limits the percentage of overrun (20) Low overrun is reported with the use of frozen butter (21) and high overrun is reported with the use of spray type NFDM (8) In this study, the amount, and possibly the frozen state, of the butter appeared to be the major factors affecting the percentage of overrun in the soft-serve ice milk mixes. Mixes one and three were lower in percentage of overrun than mixes two and four These data suggest that the higher percentages of butter in mixes one and three produced greater fat aggregation and subsequent greater weakening of the lamellae

Taste Panel Reliability and Validity For descriptive sensory analysis, no absolute number of panelists is recommended, 10 have been suggested (22) or between 6 and 12 subjects are reported to be adequate (23) Trained judges have been reported to be more sensitive to visual and tactile factors in sensory evaluation than untrained judges (24), and to be able to evaluate designated flavor defects in ice cream and other dairy foods comparatively close to evaluations of expert judges (25) The eight panelists in this study were selected by appropriate triangle tests (10) and trained according to suggested guidelines (24) Significant differences between taste panel scores are expected in quantitative descriptive analysis, however, consistent panelist performance is critical (14) Consistent scoring was reported for mixes two, three, and four as no significant differences were found between each mix's overall quality scores from tasting sessions 1-6 and 7-12 (Table 4) Inconsistent scoring was found, however, for mix one Mix one's overall quality score was significantly ($P \leq .001$) different between tasting sessions 1-6 and 7-12 The means of the overall quality scores for tasting sessions 1-6 and 7-12 were not significantly different, consequently, the taste panel was concluded to be reliable. Taste panel validity was also established Of the four mixes, panelists scored mixes one and two the highest and lowest respectively (Table 7), and reported the greatest and least preferences for mixes one and two respectivey (Table 8) Mix four scored the second highest of the four mixes but was third in preference and mix three scored third highest but was second in preference However, no significant differences were reported among the overall quality scores for mixes one, three, and four

Descriptive Evaluation Differences in the sensory properties of the ice milk mixes revealed a significantly different mean ($P \leq$ 001) for the body of mix two (Table 5) Panelists reported the body of mix two to be watery (Table 6) Watery body may be due to low total solids and/or insufficient stabilizer in the mix In this study, all mixes contained 0 3 percent emulsifier/stabilizer combination and, mixes one, two, three, and four contained 33 1, 30 7, 30 1, and 27 7 percent total solids respectively (Table 1) The body in mixes two, three, and four were reported to be watery more frequently than in mix one (Table 6), however, only mix two scored significantly different for body High quality body is also associated with some butterfat agglomeration (26) which would be lessened in mixes two and four due to lower percentages of butterfat in those mixes Consequently, the watery body observed in mix two could be partially due to low total solids plus low butterfat agglomeration

In determining the two mixes of highest quality, the overall quality scores were considered (Table 7) The range of possible scores was 0 to 2400 If scores above and below 1200 are considered desirable and undesirable respectively, all four mixes were acceptable with mix two the least acceptable. Mix two was eliminated, however, due to the significantly different overall quality score (Table 7) and significantly different mean score for body (Table 5) compared to the other mixes

While no significant quality differences were reported between mixes one, three and four (Table 7), mixes one and four were selected as the two highest quality mixes because they scored the highest overall quality scores. Additional factors considered in this determination included the percentage of butter and NFDM utilized in mix one, and mix four's nutritional values (Table 9). Mix one contains a larger percentage of NFDM than mix three and, therefore, provides a greater potential to use the vast uncommitted stocks of NFDM. Mix four, with only three percent butterfat, contains fewer calories and fat than mix three and more closely approximated the caloric and fat composition of commercial ice milk (27). Mixes one and four also represent the greatest differences in percentage of butterfat and NFDM and are expected to produce more easily detectable differences when judged for acceptability by secondary students in another study (CHAPTER IV). Difficulty in scoring is expected when the products are not very different from each other (14) and judges are reported to prefer to find differences (24) and may grow discouraged or lose interest when no differences can be detected.

Summary

Descriptive quantitative analysis revealed no significant differences among any of the sensory properties of soft-serve ice milk mixes one, three, and four. Mix two scored significantly different than the other mixes for body. Mixes one and four were determined to be the two highest quality mixes based on their overall quality scores. Mix one was also selected due to its potential for using more USDA bonus commodity NFDM and butter than mixes three and four. Mix four was favored due to its lower caloric and fat values than mixes one and three.

Table 1
Composition of Vanilla Soft-Serve Ice Milk Mixes

	Ice Milk Mixes			
	1	2	3	4
USDA butter (%)	6.0	3.0	6.0	3.0
USDA NFDM (%)	14.0	14.0	11.0	11.0
sugar (%)	14.0	14.0	14.0	14.0
emulsifier/stabilizer (%)	0.3	0.3	0.3	0.3
total solids (%)[a]	33.1	30.7	30.1	27.7
water (%)	65.7	68.7	68.7	71.7
vanilla (ml/gallon)	18.0	18.0	18.0	18.0

a On the basis of butter containing 20% water

Table 2
Basic Formula and Modifications for Triangle Tests

Basic Formula
375 ml fluid whole milk (3 2% fat)
55 g granulated sugar
2 ml imitation vanilla
0 7 g salt

Color Modification
basic formula
2 drops yellow food coloring

Sweetness Modification
375 ml fluid whole milk (3 2% fat)
165 g granulated sugar
2 ml imitation vanilla
0 7 g salt

Salt Modification
375 ml fluid whole milk (3 2% fat)
55 g granulated sugar
2 ml imitation vanilla
2 g salt

Flavoring Modification
375 ml fluid whole milk (3 2% fat)
55 g granulated sugar
6 ml imitation vanilla
0 7 g salt

Freshness Modification (cooked flavor)
basic formula heated to boiling and boiled for two minutes with continuous stirring

Texture Modification
375 ml fluid skim milk ($\leq$ 0 5% fat)
55 g granulated sugar
2 ml imitation vanilla
0 7 g salt

Body Modification
basic formula allowed to stand at room temperature for five minutes after freezing

<u>Freezing Directions</u>

Pour mix into 4-quart freezer can, adjust dasner and lid, place in freezer bucket Add salt and ice in proportions of 1 12 by volume Add one third of ice to bucket before adding any salt, alternate layers of salt and remaining ice Keep the level of salt and ice slightly higher tnan the level of mix in the can

Table 3
Analysis of Variance Among Percentages of Overrun
in Soft-Serve Ice Milk Mixes

Mix Number	% Fat-% NFDM	Mean[a] % Overrun
1	6%-14%	31 63
2	3%-14%	45 37
3	6%-11%	35 34
4	3%-11%	43 88
Between Mean Squares (3df)		94 71
Within Mean Squares (4df)		210 38
F Ratio		0 113
P > F		NS[b]

a 2 replications
b Not Significant

Table 4
Analysis of Variance Between Soft-Serve Ice Milk Overall Quality Scores From Tasting Sessions 1-6 and 7-12

	Overall Quality Score[a]					
	Session 1-6	Session 7-12	df	Mean Square	Ratio	P>F
Mix 1	1808 33	2175 63	1	1618838 0	21 6	001
Mix 2	1802 29	1832 08	1	10650 5	089	NS[b]
Mix 3	1931 67	1995 0	1	48133 3	487	NS[b]
Mix 4	2032 50	1928 75	1	129168 8	1 14	NS[b]
Overall Quality Mean[c]	1893 70	1982 86	1	381633 3	3 432	NS[b]

a N = 24 (3 evaluations x 8 panelists)
b Not significant
c N = 96 (24 evaluations x 4 mixes)

Table 5
Analysis of Variance Among Sensory Property Mean Scores[a]
for Soft-Serve Ice Milk Mixes

Sensory Property	Mix No	Mean	Between Mean Squares	Within Mean Squares	F Ratio	P>F
Color	1	347 3	1771 0	3258 9	544	NS[b]
	2	340 1				
	3	348 8				
	4	354 9				
Sweetness	1	312 7	1375 0	6780 3	203	NS[b]
	2	313 8				
	3	321 6				
	4	323 2				
Freshness	1	332 5	5931 6	8072 3	735	NS[b]
	2	308 9				
	3	329 4				
	4	331 3				
Flavor	1	314 4	4158 4	5955 8	698	NS[b]
	2	325 0				
	3	320 3				
	4	336 4				
Texture	1	350 2	14162 3	7889 8	1 795	NS[b]
	2	315 9				
	3	329 8				
	4	312 3				
Body	1	334 9	135644 8	1929302 1	13 148	001
	2	217 9[c]				
	3	313.5				
	4	322 6				

a N = 48 (6 evaluations x 8 panelists)
b Not significant
c Significantly different from other mixes

Table 6
Frequency of Descriptive Terminology for Sensory Properties Judged by Panelists To Be Less Than Desirable

Sensory Properties	Frequency Mix 1	Mix 2	Mix 3	Mix 4
Color				
pale	8	9	6	6
dark	0	0	0	0
Sweetness				
insufficient	1	0	1	3
excessive	9	5	6	6
Flavoring				
weak	3	3	0	2
excessive	5	5	4	3
Freshness				
stale	0	0	0	1
Texture				
sandy	5	8	10	13
icy	0	0	1	3
Body				
foamy	1	3	2	2
watery	5	24	9	10

Table 7
Analysis of Variance Among Overall Quality Scores
of Soft-Serve Ice Milk Mixes

	MIX			
	1	2	3	4
Quality Score[a]	1991 98	1817 19[b]	1963 33	1980 63
Between Mean Square (3 df)				319476 4375
Within Mean Square (188 df)				109319 3594
F Ratio				2 922
P > F				05

a N = 48 (6 evaluations x 8 panelists)
b Significantly different than other mixes

Table 8
Panelists' Personal Preferences Among
Soft-Serve Ice Milk Mixes

Mix Number	Frequency of Personal Preference[a]	χ^2 (3df)
1	30	8 58[b]
2	12	
3	29	
4	25	

a N = 96 (12 evaluations x 8 panelists)
b Significant at the 05 level of confidence

Table 9
Selected Nutritional Values[a] in Bonus Commodity
Soft-Serve Ice Milk

Values per cup	Ice Milk Mixes 1	3	4
Calories	295 2	269 5	219 0
Protein (g)	10 3	8 5	7 9
Fat (g)	9 8	9 4	4 6
Carbohydrate (g)	43 1	38 9	37 4
Cholesterol (mg)	31 2	29 4	15 9
Calcium (mg)	356 0	292 0	279 0

a Nutrient values for the NFDM, butter, and sugar were taken from Posati and Orr (27), Reeves and Weihrauch (28), and Watt and Merrill (29) respectively

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CHAPTER IV

ACCEPTANCE OF SOFT-SERVE ICE MILK MADE FROM USDA BONUS COMMODITY NONFAT DRY MILK AND BUTTER

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Abstract

Two vanilla soft-serve ice milk mixes utilizing USDA commodity nonfat dry milk (NFDM) and butter were developed for on-site preparation in the National School Lunch Program (NSLP). Both mixes contained 14% sugar, 0.3% emulsifier/stabilizer combination, and 18 ml imitation vanilla per gallon. The high butter/high NFDM mix contained 6% butter and 14% NFDM, in contrast to the low butter/low NFDM mix which contained 3% butter and 11% NFDM. The mixes were evaluated for consumer acceptability by a convenience sample of 2014 junior and senior high school students. Consumer acceptability evaluation revealed that 54.1% of the students preferred the low butter/low NFDM mix. All but one sample met the regulatory standards for commercial ice milk for total bacteria ($\leq$ 50,000/g), all samples met the standards for coliform ($\leq$ 10/g).

Introduction

The success of the National School Luncn Program (NSLP) in providing nutritious lunches for school age children and in utilizing USDA commodities depends on student participation Competitive foods rival the NSLP for student participation If school foodservice operations are to succeed in maintaining and increasing student participation, they need to serve good tasting nutritious foods that are popular with school age children The purpose of this study was to test the acceptability of soft-serve ice milk, made from USDA commodity NFDM and butter, with secondary students in the NSLP

With a per capita consumption of 22 quarts annually, ice cream ranks as a popular American dessert (1) Nine out of 10 children, through age 12, reported ice cream to be their number one favorite food (2) Ice milk, however, has grown in popularity due to consumer concerns for cost and nutrition (3) Ice milk retails at a lower price than ice cream because of lower butterfat percentages, and nutrition conscious consumers prefer the lower caloric and fat levels of ice milk over ice cream Since 1978, ice milk has been produced primarily as a soft-serve product (4) and is widely available in fast food outlets, soft-serve stores, and schools The service of soft-serve ice milk in schools is a result of efforts to offer greater menu variety in order to attract student participation A larger variety of choices is available within each of the lunch components, however, milk choices offer the greatest variety and include lowfat, nonfat, buttermilk, chocolate low fat, regular homogenized, and soft-serve ice milk shakes (5)

In the production of an ice milk product, the selection of amounts and types of ingredients and the sanitary conditions of mixing and freezing are of paramount importance The final test is, however, the reaction of the consumer (6) Untrained individuals, representative of the average consumer, can rank samples from best to poorest on the basis of their own standards

Method

Research design

In a previous study (CHAPTER III), a trained taste panel selected two soft-serve vanilla ice milk mixes (Table 1) to be evaluated for acceptability by secondary students Students evaluated the ice milk mixes by paired comparisons To assess the external validity of the taste panel's selections, the taste panelists predicted which one of four original mixes would be preferred by secondary students Taste panel predictions were recorded on the Ice Milk Evaluation Form (Appendix B)

Subjects

During the spring of 1986, secondary students were selected by convenience sampling from students purchasing the school lunch in four junior high and three senior high schools in Lawton, Oklahoma The approximate enrollment in these seven schools as of April 1986 was 7500 students (Appendix E) All students were invited to evaluate the soft-serve ice milk by means of an announcement (Appendix F) read over the school's public address systems or in individual classrooms on each specified evaluation date Despite not being randomly selected, the study's sample was appropriate for the study as the subjects were untrained, members of the target population, and consumers of the test product (7)

The sample consisted of 2199 students who completed the evaluation, however, due to missing data, only 2014 (91 5%) of the evaluations were usable for analysis Adequate sample size is reported to be between 50 and 100 members (7)

Ice milk preparation

The vanilla soft-serve ice milk mixes were prepared utilizing USDA bonus commodity Extra Grade NFDM and butter, donated to the study through the USDA Regional Office in Dallas, Texas, as the sole sources of nonfat milk solids (NFMS) and butterfat respectively The mixes were sweetened with granulated sugar (sucrose), flavored with imitation vanilla flavoring, and emulsified with an emulsifier/stabilizer combination The NFDM was spray processed and produced between March and June of 1984, the butter was salted and produced in March and June of 1985 The NFDM was packaged in 50 pound paper bags with plastic liners and was stored tightly closed and away from light One pound packages of butter were stored frozen in a home size refrigerator/freezer at 18°F (-8°C) The mixes were prepared the afternoon of the day before the evaluation in 6-, 7- or 10-gallon volumes, depending on each school's enrollment (Appendix E) The dry ingredients and butter were measured by weight, liquid ingredients were measured by volume The mixes were prepared according to the mixing directions shown in Table 1 The prepared ice milk mixes were cooled in 4-gallon containers, lined with plastic bags, at room temperature (70°F (21°C)) until the mixes thickened sufficiently to prevent the butterfat from separating The plastic bags were then sealed, the containers were covered with tight fitting plastic lids, and refrigerated at 36-38°F (2-3 5°C) overnight in an institutional walk-in refrigerator The cooled mixes were transported to each junior and senior high school and immediately frozen in identical Taylor ice cream freezers Prior to freezing, each ice cream freezer was assembled and sanitized for two minutes with 100 ppm chlorine solution (8)

Data collection

Students were simultaneously served one sample of each mix in 2-ounce white paper cups accompanied by a wooden spoon Samples were coded with a circle or a square and the coding of samples was alternated at each school The students were not instructed on whether to evaluate the ice milk before or after eating lunch or on which sample to evaluate first The students reported their ice milk preference, age and sex on the Soft-Serve Ice Milk Evaluation form (Appendix B) developed for this study Students' preferences for the high butter/high NFDM mix and the low butter/low NFDM mix were coded as one and four respectively, age was coded as the actual two-digit response, boys and girls were coded one and two respectively, and the schools were coded one through seven One sample of each soft-serve ice milk mix was collected from each school and tested for total bacteria count and coliform count by procedures outlined in Standard Methods for the Examination of Dairy Products (9)

Data analysis

Students' acceptability responses between the two soft-serve ice milk mixes were analyzed for statistical significance by Chi square (10) All hypotheses were tested for significance at the 5 percent ($P \leq 05$) level

Results and discussion

External validity

Taste panelists who evaluated the ice milk mixes for quality (CHAPTER III) predicted a significant ($P \leq .01$) difference among the ice milk preferences of the secondary students (Table 2). Ranked in order of preference, taste panelists predicted secondary students would prefer mixes three, one, four and two. In the acceptability evaluation by secondary students, however, only the two highest quality mixes, mixes one, high butter/high NFDM, and four, low butter/low NFDM, were tested. A significant difference ($P \leq .001$) was found between the students' preference for mix one, high butter/high NFDM, and mix four, low butter/low NFDM (Table 3), with the majority (65.7%) of the secondary students preferring mix four, low butter/low NFDM. The external validity assessment was concluded to be invalid because the taste panel was unrepresentative of the secondary school population (11). Taste panelists had been trained to recognize the desirable sensory properties of soft-serve ice milk, secondary students did not receive this training and evaluated the mixes based only on their own preferences (6).

Consumer acceptability evaluation

Approximately 65% of the students ($P \leq .001$) indicated a preference for the low butter/low NFDM mix (Table 3). A greater sensation of coldness in the low butter/low NFDM mix may provide one possible explanation for the students' preference as consumers report preferences for ice cream served at 10°F (-12°C) over ice cream at 6, 14, or 18°F (-14.5, -10, -8°C) (12). Low fat ice cream reportedly feels colder in the mouth than high fat ice cream (13), correspondingly, ice milk containing 3%

butterfat would feel colder than ice milk containing 6% butterfat A greater sensation of warmness is also associated with serum solids at 15 5% concentrations (12) The high percentage of fat together with 14% NFDM may have produced a noticeable difference in the sensations of coldness between the two mixes even when dispensed between 18 and 22°F (-8 and -5 5°C) Another explanation for the students' preference for the low butter/low NFDM mix may be the degree of perceived sweetness The low butter/low NFDM mix, containing fewer total solids than the high butter/high NFDM mix would be expected to taste sweeter Sommer (14) reported younger individuals prefer sweeter ice cream The composition of the low butter/low NFDM mix may further explain the students' preference for the low butter/low NFDM mix over the high butter/high NFDM mix The composition of the low butter/low NFDM mix closely approximates the composition of commercial ice milk (15) and may, therefore, have tasted familiar to the students

Ice cream body is a determining influence on consumer preference and, subjects preferring lighter ice cream were expected to prefer samples with lower concentrations of either fat or serum solids and vice versa (6) At 18°F, consumers preferred the body of ice creams containing 9 and 11% serum solids and 14 and 18% fat (13) The sensations of richness and heaviness due to the concentrations of butter and serum solids in the body of the high butter/high NFDM mix would not be preferred by students preferring lighter products

Age was found to significantly ($P \leq 0001$) affect ice milk preferences (Table 4) All ages preferred the low butter/low NFDM mix, and, for ages 12-16, the percentage of students preferring the low butter/low NFDM mix increased with age In comparing junior high to senior high students (Table 5), 61 7 and 74 5% of junior high and senior high students respectively preferred the low butter/low NFDM mix ($P \leq$ 0001) A greater percentage of senior high students preferred the low butter/low NFDM mix than junior high students These data suggest that older students have a greater preference for low butter/low NFDM soft-serve ice milk than younger students Sex was also found to have an effect on the preference for the low butter/low NFDM mix (Table 6) While both males and females preferred the low butter/low NFDM mix, the preference was significantly ($P \leq$ 0001) higher for females than males The differences due to age and sex could be related to the students' level of nutrition awareness. Older students and female students are expected to be more conscious of fat and caloric values in rich, heavy bodied ice cream and, therefore, would be expected to prefer the product with a lighter body due to lower concentrations of butterfat and NFDM

Bacteriological testing

Bacteriological data (Table 7) revealed that all but one of the samples tested were below the suggested regulatory standards of $\leq$ 50,000/g for total bacteria Coliform counts, excluding the spreaders, were all within the suggested standards of $\leq$ 10/g (16) Previous studies (17-18) report the greatest variation for total bacteria and coliform counts to occur between the soft-serve mix versus the frozen product The higher bacteria and coliform counts found in the frozen samples, compared to the unfrozen mixes, were concluded to result from inadequate cleaning and sanitizing of the soft-serve freezer and/or failure to keep the ice milk mix properly refrigerated In the current study, bacterial data from the unfrozen ice milk mixes were not collected, however, excluding the spreader plates, 90% of the frozen samples met the suggested sanitation guidelines for total bacteria and 100% met the standards for coliform These data suggest that all but one of the unfrozen mixes were within the suggested standards Samples 494 and 491 were collected from 10-gallon quantities of mix Ten gallons of each mix was the largest quantity mixed during the study The cooling time for 10 gallons of mix was longer than for the other quantities of 4 to 7 gallons and could account for the larger total bacterial counts for these two samples In actual foodservice operations, prolonged cooling times could be avoided due to the availability of quantity food equipment and institutional refrigerators capable of accommodating the volume of mix It is recommended that the mix be cooled at a depth of 2-4 inches in covered stainless steel modular pans, refrigerated on wire shelving at 38-40°F (3 5-4 5°C) Frequent stirring during the cooling process would hasten lowering the temperature of the mix

Applications and implications

Results of this study indicate the feasibility of producing a soft-serve ice milk, mixed and frozen on-site in school foodservice operations, made from USDA bonus commodity NFDM and butter that is acceptable to secondary students From a bacteriological standpoint, it appears possible to produce the soft-serve ice milk within the suggested sanitary guidelines when the mix is stored properly and the soft-serve freezer is properly sanitized Consequently, the study implies that the soft-serve ice milk is one way of utilizing bonus commodity NFDM and butter in the NSLP A further implication of the study is the possibility of increasing the calcium content of the school lunch menu Consumption of bonus commodity NFDM, in the form of soft-serve ice milk, would add to the calcium intakes of school age children

Table 1 Composition of soft-serve ice milk mixes

ingredients	high butter/high NFDM	low butter/low NFDM
USDA Butter (%)	6.0	3.0
USDA NFDM (%)	14.0	11.0
sugar (%)	14.0	14.0
emulsifier/stabilizer (%)*	0.3	0.3
total solids (%)†	33.1	27.7
water (%)	65.7	71.7
vanilla (ml/gallon)	18.0	18.0

mixing directions over high heat, heat water, frozen butter, and emulsifier/stabilizer to 185°F (85°C). Mix NFDM and sugar together and add gradually to hot mixture Stir with wire whisk or electric mixer until thoroughly mixed, add vanilla and mix Chill to 40°F (4°C) before freezing

*Southern Special donated by Go Products, San Antonio, TX
†On the basis of butter containing 20% water

Table 2 Secondary students' predicted soft-serve ice milk preferences

mix	frequency of predicted preferences*	χ^2 (3df)
1 (high butter/high NFDM)	30	16 59†
2 (low butter/high NFDM)	7	
3 (high butter/low NFDM)	32	
4 (low butter/low NFDM)	27	

*n = 96 (12 evaluations x 8 panelists)
†significant at the 01 level of confidence

Table 3 Secondary student preferences between soft-serve ice milk mixes

mix	count	%	χ^2 (1 df)
high butter/high NFDM	673	34 3	194 46*
low butter/low NFDM	1291	65 7	
total	1964†	100 0	

*Significant at the 001 level of confidence
†50 students did not prefer either mix (n = 2014)

Table 4 Soft-serve ice milk preference between ages of secondary students

	mix						
	high butter/ high NFDM		low butter/ low NFDM		total		
age	count	%	count	%	count	%	χ^2(7df)
12 & under	57	40 1	85	59 9	142	7 2	1985 39*
13	191	40 0	287	60 0	478	24 3	
14	141	36 2	248	63 8	389	19 8	
15	104	29 6	247	70 4	351	17 9	
16	74	27 8	192	72 2	266	13 5	
17	53	29 4	127	70 6	180	9 2	
18 & over	53	33 8	105	66 8	158	8 0	
total					1964†	99 9††	

*significant at the 0 0001 level of confidence
†50 students did not prefer either mix (n = 2014)
††total does not equal 100% due to rounding

Table 5 Soft-serve ice milk preference of junior and senior high students

school	mix: high butter/ high NFDM count	mix: high butter/ high NFDM %	mix: low butter/ low NFDM count	mix: low butter/ low NFDM %	total count	total %	χ^2(1df)
junior high	516	38 3	832	61 7	1349	68 7	31 18*
senior high	157	25 5	459	74 5	615	31 3	
total					1964†	100 0	

*significant at the 0 0001 level of confidence
†50 students did not prefer either mix (n = 2014)

Table 6 Soft-serve ice milk preference of male and female junior and senior high students

	mix						
	high butter/ high NFDM		low butter/ low NFDM		total		
sex	count	%	count	%	count	%	χ^2(1df)
males	414	38 4	663	61 6	1077	54 8	23 57*
females	259	29 1	628	70 8	887	45 2	
total					1964†	100 0	

*significant at the 0 0001 level of confidence
†50 students did not prefer either mix (n = 2014)

Table 7 Standard plate and coliform counts of frozen soft-serve ice milk

sample no	standard plate count	coliform count
420	1300	10
441	4000 Est	---- spr *
444	---- spr *	10
471	4000	<10
474	28000	<10
494	>65000 Est	---- spr *
491	20000 Est	10
4111	80	<10
4114	<10 Est	<10
4144	200	---- spr *
4141	3000	<10
4160	2700	<10

Percentage† within suggested sanitary guidelines

standard plate	90
coliform	100

*spreader and adjoining area of repressed growth covering more than one half of plate

†excluding spreaders

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CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

The objective of this study was to investigate the possibility of utilizing USDA commodity NFDM and butter to produce a soft-serve ice milk mix to be prepared on-site in school foodservice operations and to evaluate the acceptability of this ice milk by secondary students Two hypotheses related to the study were made prior to the start of the experiments (CHAPTER I) Each hypothesis will be discussed individually

Hypothesis one stated that the soft-serve ice milk quality scores would not differ significantly among the mixes when descriptively evaluated by a trained taste panel No significant differences were found between three of the mixes, however, one mix scored significantly different than the others for body and overall quality (CHAPTER III) Based on these results, the first null hypothesis was rejected

Hypothesis two stated that secondary students would not prefer one soft-serve ice milk mix significantly over the other A signifcant difference was found between the number of students preferring the low butter/low NFDM mix and the high butter/high NFDM mix (CHAPTER IV) This difference was confirmed by all age groups and by both males and females Consequently, the second null hypothesis was rejected

These two experiments (CHAPTER III and CHAPTER IV) positively support the possibility of individual school foodservice operations utilizing USDA bonus commodity NFDM and butter in a soft-serve ice milk mix that is acceptable to secondary students The highest quality mix preferred by secondary students contained the following ingredients

NFDM	11 0%
butter	3 0%
granulated sugar	14 0%
emulsifier/stabilizer	0 3%
imitation vanilla	18 0 ml/gallon
water	71 7%2

Production of bonus commodity soft-serve ice milk would assist the NSLP achieve the objectives of providing nutritious meals to the Nation's children and encouraging the consumption of agricultural commodities

Nutritional value of menu items is a major focus in the NSLP Martin (1984) criticized processing commodities into high fat, sugar, and salt foods due to concern over tooth decay, obesity, and heart disease The bonus commodity soft-serve ice milk provides a concentrated source of food energy due to its fat and sugar contents, however, Reiter (1986) reported that ice milk is easily rinsed from the mouth Therefore, the bonus commodity soft-serve ice milk is less likely to cling to the tooth's surface and promote decay than many other sweet treats In addition, the bonus commodity ice milk developed contains three percent butterfat and, consequently, is more acceptable than ice cream which contains 10-16 percent butterfat (Posati and Orr, 1976) for routine inclusion in the diet While bonus commodity ice milk is not sufficiently nutritious to replace more nutrient dense foods, one cup adds 279 mg (Table 9, CHAPTER II) of calcium to the diet, and calcium intakes for most school-age children fall below their respective RDAs (Putnam and Van Dress, 1982)

In addition to its nutritional merits, bonus commodity soft-serve ice milk could increase the positive market support for commodity foods Commodity support is computed by comparing the amounts of each commodity prepared for school feedings with estimated amounts of what would be used if the children brought their lunches from home, ate at home, or in commercial restaurants (Nelson, and Zellner, 1981) For the school year 1977-78, positive support for ice cream, ice milk, and sherbet totaled 183 9 million pounds, however, NFDM accounted for only one cent out of each 32 cents spent on dairy foods used in the Nation's schools Incorporation of bonus commodity soft-serve ice milk into school menus would increase the use of NFDM

Recommendations for Further Research

The findings of this dissertation suggest the need for additional research in three areas First, it is recommended that the research be conducted in a laboratory equipped with institution size equipment Preparing the mix in quantity food equipment would allow refinement of the mixing and cooling procedures

A second recommendation is the need to investigate the impact of mixing the soft-serve ice milk on the labor hour cost in school foodservice operations One factor accounting for the low use of NFDM in the NSLP is the number of labor hours involved in producing acceptable menu items from NFDM (Pannell, 1985) Labor hours increase when less convenience foods are used in menu preparation School foodservices preparing food on-site with limited use of convenience foods and few disposables need to average a labor hour cost between 30 and 35 percent of the total income (VanEgmond-Pannell, 1981)

It is further recommended that flavored varieties of the bonus commodity soft-serve ice milk be developed using other commodity foods, such as fruits and peanut butter Flavored options will enhance menu variety and will promote additional commodity market support

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APPENDIX A

PRELIMINARY EXPERIMENTS

Preliminary Experiments

Experiment 1

The following ice milk mixes were tested using USDA bonus commodity NFDM and butter as the sole sources of NFMS and fat respectively Each mix was sweetened with granulated sugar (sucrose), stabilized with unflavored gelatin, and flavored with imitation vanilla (18 ml/g)

	Mix 1	Mix 2	Mix 3	Mix 4
fat	6 0%	3 0%	4 0%	2 0%
NFDM	13 0%	14 0%	11 0%	11 0%
sugar	13 0%	14 0%	14 0%	14 0%
gelatin	0 5%	0 5%	0 35%	0 5%

Mixing directions - mix sugar, NFDM, and gelatin together Add sugar mixture gradually to water, stirring constantly over low heat Heat mixture to 95°F Refrigerate overnight Remove approximately 2 quarts of the chilled mixture, add the frozen butter, and heat until butter is melted Beat the butter mixture with an electric mixer until thoroughly mixed, quickly add the butter mixture to the remaining chilled mixture, stirring constantly Add the imitation vanilla and freeze

Findings

1 Occasional butter clumps were found in the soft-serve ice milk It was concluded that a more satisfactory emulsifier and/or stabilizer is needed for complete emulsification of the butter and to simplify the mixing procedure

2 The amounts of sugar, flavoring and emulsifier need to be held constant in all mixes, allowing only the butter and NFDM to vary

3 An off-flavor was detected, consequently, a more recent issue of NFDM needs to be tested

A review of the literature revealed wide variation in the amounts of ingredients used in ice milk mixes

Butterfat - Keeney and Dahle (1960) and Arbuckle (1972) reported the most common range of butterfat in ice milk to be 3-6 percent

NFMS - Keeney and Dahle (1960) reported the range of NFMS to average 12-14 percent, Arbuckle (1972) suggested 11 5-14 percent

Sugar - Concentrations of sugar in ice milk were reported as follows Arbuckle (1972) - 13-14 percent, Keeney and Dahle (1960) - 11-13 percent, Kloser and Keeney (1959) - 13 percent, and Lampert (1970) - 14-18 percent Reid, et al, reported ice cream, served at 18°F, containing 12 percent sugar to be the preference of consumers, however, Sommer (1951) stated that younger people prefer a sweeter ice cream than older individuals

Emulsifier/Stabilizer - Legal maximums of emulsifiers in ice cream and ice milk are 0 1 percent for polys and 0 2 percent for monos (Bassett, 1969)

Flavoring - Alexander (1981) utilized 12 ml vanilla per gallon of ice milk mix, Arbuckle (1972) reported 4-6 ounces per 5 gallons of mixes containing 12 percent butterfat and suggested additional vanilla for mixes of lower butterfat concentrations

The following percentages of ingredients were selected for testing in the study butter 3-6 percent, NFDM 11-14 percent, sugar 14 percent, emulsifier/stabilizer - to be decided, vanilla 18 ml/g

Experiment 2

The following products were tested for use as the emulsifier/stabilizer in the ice milk mixes

CENTROPHASE HR-2 - a highly concentrated, medium viscosity, heat-resistant lecithin, donated to the study by

Central Soya
P O Box 1400
Ft Wayne, Indiana 46801

SOUTHERN SPECIAL EMULSIFIER/STABILIZER COMBINATION - mono and diglycerides, cellulose gum, guar gum, calcium sulfate, carrageenan, polysorbate 80, locust bean gum, and polysorbate 65, standardized with dextrose, donated to the study by

Go Products
San Antonio, Texas

Centrophase HR-2 and Southern Special were used as the emulsifier in an ice milk mix containing 6 0 percent butter and 14 percent NFDM

Findings

1 The Centrophase HR-2 mix was combined, heated to 185°F, and cooled to 40°F During the cooling period, the butter did not remain emulsified, consequently, the mix was discarded without freezing

2 The Southern Special was combined with the water and frozen butter, and heated to 185°F, the NFDM and sugar were combined and gradually added to the Southern Special mixture until thoroughly blended, the vanilla was added and the mix chilled to 40°F The mix remained emulsified during cooling and subsequent solf-serve freezing

Experiment 3

Using Southern Special as the emulsifier and varying the issue date of the NFDM, an ice milk mix containing 6 0 percent butter and 14 0 percent NFDM was tested as follows

	Southern Special (%)	NFDM (date)
Mix A	0 3	1983
Mix B	0 3	1984
Mix C	0 2	1984
Mix D	0 4	1984
Mix E	0 5	1984

Findings

1 In comparing mixes A and B, mix B was judged superior in flavor It was concluded that the more recent issue NFDM would produce the highest quality flavor in the soft-serve ice milk

2 In comparing mixes B-E

a) C was eliminated as it produced a wetter product with an unsatisfactory melt-down

b) E was eliminated as the mix was too viscous to satisfactorily flow into the soft-serve freezer's freezing chamber and the frozen product was too melt resistant

c) Mixes B and D produced satisfactory products

Experiment 4

Using the following concentrations of butter and NFDM, the concentration of Southern Special was varied between 0 3 and 0 4 percent

	Mix A	Mix B	Mix C
butter	6 0%	3 0%	6 0%
NFDM (1984)	14 0%	11 0%	11 0%

Mix D was prepared using 0 3 percent Southern Special, 6 0 percent butter, and 14 0 percent commercial (Carnation) NFDM

Findings

1 In comparing mixes A and D, no discernable differences were noted in flavor It was concluded that the flavor of the ice milk is not due entirely to the age of the NFDM

2 In comparing the two levels of Southern Special, no advantages were apparent in the soft-serve product with 0 4% The viscosity of the 0 4% mixes was judged to be a disadvantage It was concluded to use 0 3% Southern Special in all mixes to be tested

APPENDIX B

INSTRUMENTS

TRIANGLE TEST FOR DIFFERENCE

NAME ____

PRODUCT FROZEN ICE MILK MIXTURE

TEST FOR

Samples Presented ____ ____ ____

Two of the samples are identical, one is the odd or different sample Test to determine the odd sample If you are not sure, guess

Different/Odd Sample is ______________

Describe difference(s) in quantitative terms (e g , "Sample 25 is ____________________")

SOFT-SERVE ICE MILK SCORECARD

NAME ______________________ DATE __________ CODE __________

Please taste the ice milk sample and answer each question in sequence, placing a vertical line across the horizontal line at the point that best describes that property in the sample For those properties you judge to be less than desirable, please circle the appropriate descriptive term

After you have answered all the questions for the sample, return the sample and the scorecard and wait for the next sample

If you have any questions or need more water, ask the experimenter Thank you

1 COLOR

pale/dark |__________________________| attractive

2 FLAVOR

a) Sweetness

insufficient/excessive |__________________________| pleasing

b) Flavoring

weak/excessive |__________________________| pleasing

c) Freshness

stale |__________________________| fresh

3 TEXTURE

sandy/icy |__________________________| smooth

4 BODY

foamy/watery |__________________________| cohesive

ICE MILK EVALUATION

NAME_________________________________ DATE_________________________

1 Between the two ice milk samples evaluated today, which one did you prefer? Please circle your choice

2 Between these same two samples, which one would you predict to be preferred by secondary level school children? Please circle your choice

SOFT-SERVE ICE MILK EVALUATION

1 Please place a checkmark beside your age and sex

AGE		SEX	
______	12 or under	______	male
______	13	______	female
______	14		
______	15		
______	16		
______	17		
______	18 or over		

2 One cup of ice milk is marked with a circle the other is marked with a square To show which one you like the best check inside the square or circle below

□ (Please check only one) ○

APPENDIX C

TRAINING SESSION FORMULAS

TRAINING SESSION FORMULAS

COMMERCIAL FORMULA (BORDEN)

Butterfat	3 5%
Nonfat Milk Solids	12 8%
Nutrative carbohydrate Sweetener (sucrose and/or corn syrup)	13 8%
Stabilizer (gum extractives)	0 54%
Emulsifier	none

ARBUCKLE (1972) FORMULAS

Formula 1

USDA butter	6 0%
USDA NFDM	13 0%
granulated sugar	13 0%
gelatin	0 5%
imitation vanilla	12 0 ml/gallon

Formula 2

USDA butter	3 0%
USDA NFDM	14 0%
granulated sugar	14 0%
gelatin	0 5%
imitation vanilla	12 0 ml/gallon

APPENDIX D

DEFINITIONS OF SENSORY PROPERTIES

DEFINITIONS OF SENSORY PROPERTIES

COLOR

DEFINITION - visual perception or appearance readily associated with the flavor

DESIRABLE COLOR CHARACTERISTICS

delicate, true in shade
appropriate, natural for the flavor
uniform, even
VANILLA off white
color of cream

UNDESIRABLE CHARACTERISTICS

too pale
too intense
not true in shade
VANILLA egg yellow
grayish

FLAVOR

DEFINITION - blend of taste and smell sensations evolved in the mouth

DESIRABLE FLAVOR CHARACTERISTICS

rich, full flavor
creamy
delicate, natural flavoring
slightly sweet

UNDESIRABLE CHARACTERISTICS

SWEETNESS	excessive
	deficient, flat
FLAVORING	excessive, harsh or bitter
	deficient, low flavor perception
	not typical of flavor
	sharp or lingering
	artificial, not fine or delicate
FRESHNESS	old, stale
	oxidized, cardboard taste
	cooked
	metallic
	unclean
	rancid

TEXTURE

DEFINITION - feel of the product in the mouth from pressures exerted on the tongue and the roof of the mouth

DESIRABLE TEXTURE CHARACTERISTICS

smooth, uniform
solid particles too small to be detected
clean, does not coat the mouth

UNDESIRABLE CHARACTERISTICS

icy
coarse - large ununiform icy crystals
fluffy, snowy - large air cells, open texture
sandy - roughness like sand when rubbed against the roof of the mouth
buttery - lumps of butterfat easily detected
greasy - leaves an oily mouth-coating

BODY

DEFINITION - the way the product behaves when it begins to warm and melt

DESIRABLE BODY CHARACTERISTICS

melts fairly rapidly at room temperature to a smooth liquid
stands up well, firm and resistant to melting

UNDESIRABLE CHARACTERISTICS

foamy
curdy - finely divided particles in watery liquid
soggy - dense and somewhat "wet" in appearance resists melting
weak - lacks firmness, melts rapidly
crumbly - lacks cohesion, pulls or breaks apart very easily, dry

APPENDIX E

GALLONS OF ICE MILK MIX PREPARED FOR EACH SECONDARY SCHOOL BASED ON ENROLLMENT

TABLE I

GALLONS OF ICE MILK MIX PREPARED FOR EACH SECONDARY SCHOOL BASED ON ENROLLMENT*

Date	School	Gallons of Mix	Enrollment
4/2/86	Central Jr	7	1080
4/4/86	Lawton Sr	6	1242
4/7/86	Eisenhower Sr	6	1466
4/9/86	Eisenhower Jr	10	1497
4/11/86	MacArther Sr	4	599
4/14/86	MacArther Jr	7	713
4/16/86	Tomlinson Jr	7	860

*Enrollment as of April 1986 = 7457

APPENDIX F

ANNOUNCEMENT MADE IN SECONDARY SCHOOLS

ANNOUNCEMENT MADE IN SECONDARY SCHOOLS

"Today our school is part of an ice milk research project At lunch you will be served two samples of ice milk and asked to pick the one you like the best There is no charge to participate "

APPENDIX G

RAW DATA

RAW DATA FOR SENSORY EVALUATION
(CHAPTER III)

The data are arranged as follows

Column	
1-3	Panelist ID number
4-5	Tasting Session No (01-12)*
6-7	Color mean first mix
9-10	Color mean second mix
12-14	Sweetness mean first mix
15-17	Sweetness mean second mix
18-20	Flavoring mean first mix
21-23	Flavoring mean second mix
24-26	Freshness mean first mix
27-29	Freshness mean second mix
30-32	Texture mean first mix
33-35	Texture mean second mix
36-38	Body mean first mix
39-41	Body mean second mix
42	Personal preference
43	Predicted student preference

*First and second mixes were randomly assigned to the tasting sessions in the following combinations

Session No	First Mix	Second Mix
01	1	2
02	3	2
03	3	1
04	4	3
05	4	1
06	4	2
07	1	4
08	3	4
09	2	1
10	2	3
11	1	3
12	2	4

[illegible]

RAW DATA FOR ACCEPTABILITY EVALUATION
(CHAPTER IV)

The data are arranged as follows

Column 1-2	Age
3	Sex
4	Preferred Mix No
5	School Code No

[illegible]

13242	13242	13142	16243	15243	15243	12114
~~16242~~	~~16242~~	~~16242~~	~~17143~~	~~16243~~	~~15243~~	~~16214~~
13242	11[illegible]42	16242	1[illegible]11	13143	15243	13114
1624[illegible]	16142	1[illegible]242	1[illegible]143	16143	15243	4114
17142	14[illegible]	11[illegible]21	16243	1[illegible]143	1[illegible]11	15114
[illegible]14	1[illegible]242	6243	1524[illegible]	13143	1[illegible]243	15114
1[illegible]14	1[illegible]142	1[illegible]11	1[illegible]14	4[illegible]	16[illegible]43	14114
1[illegible]243	1[illegible]142	17143	1[illegible]143	16243	1[illegible]13	15214
1[illegible]142	1[illegible]4	14	16[illegible]43	1[illegible]43	1[illegible]43	[illegible]14
1[illegible]142	1[illegible]242	3143	16143	[illegible]1	1[illegible]21	14114
1[illegible]4	1[illegible]42	143	1511[illegible]	13143	[illegible]24[illegible]	15114
1[illegible]4[illegible]	1614[illegible]	161[illegible]3	16143	16143	1[illegible]243	14114
1[illegible]4[illegible]	1[illegible]42	1[illegible]243	1[illegible]4	1[illegible]243	1[illegible]43	15114
1[illegible]14	16[illegible]42	18243	13143	13143	1[illegible]24[illegible]	14114
15[illegible]42	15[illegible]42	13143	1[illegible]14	1[illegible]11	1[illegible]24[illegible]	15214
16242	16142	15143	17143	1[illegible]143	1[illegible]243	11214
15142	15142	15143	1[illegible]14	1[illegible]143	1[illegible]4	1[illegible]114
1[illegible]142	1[illegible]14[illegible]	15143	16143	16143	1[illegible]143	15[illegible]14
1[illegible]142	6142	1[illegible]143	1[illegible]14	1[illegible]11	1[illegible]24[illegible]	14[illegible]14
17143	16242	1614[illegible]	13143	6243	1[illegible]24[illegible]	14114
1[illegible]14[illegible]	15142	1[illegible]143	1321[illegible]	13143	16[illegible]4[illegible]	14214
1[illegible]14[illegible]	16142	1511[illegible]	16143	17243	1[illegible]43	1[illegible]114
1[illegible]14[illegible]	16242	1524[illegible]	1[illegible]143	1[illegible]14[illegible]	1[illegible]4[illegible]	14114
17142	15242	1[illegible]243	1[illegible]143	15143	1621[illegible]	14[illegible]14
1[illegible]42	13[illegible]42	1614[illegible]	15143	13243	1[illegible]14[illegible]	14[illegible]14
16242	1314[illegible]	16143	16143	16243	16[illegible]43	13214
1[illegible]4[illegible]	1[illegible]42	15143	1[illegible]11[illegible]	1[illegible]24	15143	1[illegible]114
17142	13242	16243	17143	1[illegible]243	16[illegible]43	14114
1[illegible]14[illegible]	1[illegible]242	1[illegible]143	1511[illegible]	16[illegible]43	17243	4[illegible]14
13142	1[illegible]42	15143	16243	16143	16143	13114
1[illegible]142	1[illegible]142	1[illegible]143	1[illegible]243	1[illegible]143	1[illegible]24[illegible]	15114
17142	18142	15143	16143	16[illegible]43	18143	12214
16[illegible]4[illegible]	16142	1624[illegible]	13243	1[illegible]24[illegible]	15143	14[illegible]14
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15242	1614[illegible]	18143	16243	16[illegible]43	13243	14214
13[illegible]42	1[illegible]4[illegible]	16243	16143	1511[illegible]	13[illegible]4[illegible]	14[illegible]14
16142	1[illegible]142	16[illegible]43	18243	1[illegible]1	13[illegible]1[illegible]	13114
15142	1[illegible]142	16243	1514[illegible]	121[illegible]	1311[illegible]	14114
1[illegible]142	15[illegible]42	15243	16113	3143	15104	14114
1[illegible]142	1[illegible]242	16143	1[illegible]11[illegible]	1511[illegible]	15204	15114
16[illegible]4[illegible]	1[illegible]42	16143	18143	16143	14204	15114
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1[illegible]43	1[illegible]242	1611[illegible]	16243	16143	1[illegible]14	11114
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15245	16115	12245	14246	1_216	3146	13246
1-245	15145	-245	13246	13116	13146	12146
245	5145	6_45	13146	13116	14_46	14246
15145	16_45	16_45	13246	13216	1_14c	15246
15_45	1-45	1-245	-246	15116	_146	14246
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VITA

Rebecca Kieffer Pazoureck

Candidate for the Degree of

Doctor of Philosophy

Thesis SOFT-SERVE ICE MILK A UNITED STATES DEPARTMENT OF AGRICULTURE BONUS COMMODITY PRODUCT FOR USE IN THE NATIONAL SCHOOL LUNCH PROGRAM

Major Field Home Economics - Food, Nutrition and Institution Administration

Biographical

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