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DIRECT ACID SET COTTAGE CHEESE WHEY AS AN EXTENDER FOR BUTTERMILK AND CHOCOLATE MILK DRINKS

by

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B.S., University of Texas, Austin, Texas, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

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Major Professor

A sincere appreciation is expressed to Dr. Richard Bassette, my major professor, and Marty Bassette for their help and interest throughout my graduate study.

Special thanks are expressed to Dr. Jean F. Caul and Dr. Daniel Y.C. Fung for their guidance, thesis editing and friendship; to Dr. James Hess for his help with the statistical analysis of the data; and to the personnel at the KSU Dairy Plant for their assistance in plant processing trials.

To Blanche and Buell Blackburn and Ralph Betancourt III my deepest thanks and appreciation are extended for their support and encouragement over the miles. Finally, many thanks are expressed to my friends here at KSU especially Bui, Jill and Gwen who have helped to make my stay here one that I will always cherish.

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INTRODUCTION

Many large milk processing plants are major polluters of municipal sewers due in part to cottage cheese acid whey and wash water dumping. Whey exerts a 30,000 - 60,00 ppm of biochemical oxygen demand (BOD) and 90% of this BOD is due to lactose (20), yet it contains about 50% of milk's nutrients (1). Of the 34.2 billion lbs of whey produced in 1976, 4.2 billion lbs was acid whey (11).

Aerobic oxidation systems may be utilized to reduce waste-water BOD by various food plants. These systems are responsible for added costs for cheeses. Only 60% of the U.S. cheese plants possess drying equipment to produce whey solids or modified whey products (19). Unfortunately, facilities for drying whey are too costly for fluid milk processing plants that manufacture cottage cheese.

The seriousness of the whey disposal problem becomes apparent when we review the 1972 amendment to The Water Pollution Act that marks 1985 as the beginning of pollutant-free water. Even today, municipal waste disposal plants must reject any effluent above 300 ppm of BOD to qualify for government subsidies (14) or levy surcharges.

By utilizing whey to extend milk in various dairy beverages, dairy plants could lessen the disposal problem and at the same time make a profit. My research centered on producing imitation dairy products utilizing direct acid set (DAS) whey from cottage cheese. These were a lowfat buttermilk and a chocolate drink based upon neutralized DAS whey, milk and ingredients common to dairy plants, and utilizing only the basic dairy

plant processing equipment.

Basic objectives were to:

1) determine if neutralized DAS why could partially replace milk in buttermilk and in a chocolate-flavored milk drink,

2) determine processing procedures for manufacturing these imitation products,

3) determine composition, flavor profiles and storage stability of these products,

4) keep cost in competition with similar dairy products and

5) determine consumer acceptance.

DAS whey from Meadow Gold Milk Plant, Topeka, Kansas was neutralized to pH 6.60-6.80 with magnesium oxide for the two imitation products. Magnesium intake according to the 1977-78 USDA survey was below the recommended dietary allowance (RDA) for all age groups (4). A ratio of three parts neutralized whey to seven parts skimmilk with added gelatin, cream and non-fat dry milk (NFDM) powder was formulated for the whey lowfat buttermilk. This product was pasteurized at 80 C for 35 min, homogenized at 1300 psi and inoculated with lactic culture #553 from Hansen's Laboratory, Milwaukee, Wisconsin.

The whey chocolate-drink contained four parts of netralized whey to six parts of whole milk with added NFDM powder and was pasteurized at 80 C for 35 min in a flowing-steam sterilizer and homogenized in an institutional type Waring blender. Both products were subsequently evaluated by consumers patronizing the Kansas State University (KSU) Dairy Bar using a combined triangle and preference test.

REVIEW OF LITERATURE

I. Utilization of Acid Whey

Before the advent of environmental controls, acid whey was dumped into rivers and streams or fed to animals. Its food ingredient potential was not realized until the Environmental Protection Agency (EPA) encouraged scientists to investigate channels for positive whey-utilization, which included liquid whey, dried whey solids and modified wheys such as partially delactosed-, partially demineralized- and dimineralized wheys.

Dried acid whey solids contain 67.4% lactose, 12.5% protein, 11.8% ash, 4% moisture, 0.6% fat and 4.2% lactic acid (28). Out of a potential 227 million lbs of solids in 1976, only 142.1 million lbs were actually processed, mainly as animal feed (Table 1,), while sweet whey solids were used more extensively especially for food supplementation (11). Dried acid whey or its derivatives are used in the following foods: fruit beverages, fermented milks, cheese such as Ricotta and Queso Blanco, cheese powders, salad dressings, cheese dips, bread, crackers, sherbets, sausage binders and process cheese foods (28). Acid whey is more difficult to dry due to its inherent acidity and is not as compatible in many food systems as sweet whey solids, although little difference exists after drying (31).

Up to a 25% replacement of nonfat dry milk by dried whey in ice cream is approved by the Food and Drug Administration (FDA), and a seven-fold increase in per capita consumption of whey solids has occurred since 1960 (19). But, with increased cheese production, stored whey solids have increased from 770 to 834 million lbs in the interval of 1970-1974 (19).

Modified acid wheys are utilized more in human foods than is the dried form (Table 1). They are produced by ultrafiltration, reverse osmosis, gel filtration and ion exchange (11). Acids, salts and/or lactose are partially or completely removed, altering some functional properties (1). Because of its nutritional similarities to human milk, modified acid whey may be incorporated into infant formulas, producing a casein-to-whey protein ratio comparable to that of human milk. It also lowers the osmolar load on the kidneys and increases the nitrogen utilization and retention (1, 37).

Whey proteins have a protein efficiency ratio of 3.2-3-4 compared to 2.5 for casein. This is partially due to the 40% greater concentration of lysine in whey protein compared with casein. Hence whey protein concentrates (WPC) at 30-60% protein provide nutritious products (28, 31). These WPC are utilized in substitute dairy blends and as supplements for dairy, bakery and beverage items (1, 28).

Liquid whey utilization constitutes a relatively small portion of the whey market. Food developments include fermented beverages, yogurt, citrus-flavored beverages and imitation milk (1, 10, 26).

Research has shown that wheys posses fertilizer value although transportation costs partially offset its benefits (19). Whey also has been utilized as an industrial binder for iron/steel pellets and whey lactose, in fermentation for a type of gasohol (1, 3). Animals are the major users of acid whey either in liquid form for water substitution or in dry form for feed supplementation (28).

Table 1. Utilization of acid-type dry whey for 1975-76.[a]

Use	Amount	
	1975	1976
	million of pounds	
For human food		
Dry whey	3.3	2.8
Modified whey	1.8	3.9
Condensed whey	3.7	1.1
Total	8.8	7.8
For animal feed		
Dried whey	5.5	7.7
Dried whey product	---	123.2
Condensed whey	1.0	3.4
Total	6.5	134.3
Grand total	15.3	142.1

[a] from Clark (11).

II. Origin and Properties of Direct Acid Set (DAS) Whey

Acid whey is the principal waste product from the manufacture of cottage cheese. Traditionally, this cheese has been a cultured product, commercially produced by introducing selected strains of lactic acid-producing bacteria into freshly pasteurized milk. A smooth coagulum is formed which is subsequently cut and cooked to produce curds and an acid whey. The curd flavor is bland, being slightly acidic, due to developed lactic acid, which is accompanied by a mild diacetyl taste and odor. The whey is yellow/green in color and has an acidic taste and odor.

The culture method for cottage cheese manufacture is time consuming and subject to difficulties that range from low yields to complete failure in the manufacturing process. Most of these problems are associated with maintaining viable, uninhibited growth of the lactic culture. Prior to inoculating milk in the vat, starter organisms are propagated to yield pure strains and to provide sufficient inoculum for 0.5-1.0% starter culture in 50-2,000 gallons of milk. Special tanks for propagation of cultures and extra labor are required to guard against phage and contamination that could render the cheese unmarketable. In addition to microbial contaminants, antibiotics in milk can play havoc with starter cultures and lead to vat failure (17).

Researchers have been pursuing an alternative method that would produce the desired bland, clean flavor of cultured cottage cheese but would allow more efficient and economical use of equipment, personnel and milk. In 1909, hydrochloric acid was substituted for bacterial-lactic acid, and

although unsuccessful, it laid the groundwork for research based on acidogens, enzymes, and other methods for replacement of the traditional culture method.

Deanne and Hammond (13), in 1960, tested such acidogens as anhydrides, esters, lactones and lactides as replacers of culture lactic acid. D-glucono-delta-lactone (GDL), added at 12.3% of milk's solids not fat (SNF), was found to hydrolyze slowly to gluconic acid with a final pH of 4.6. However, it required 15 hours at 20 C or 4.5 hours at 40 C to produce the desired coagulum. Adding rennet reduced setting time, since the curd could be cut at a higher pH. The product was bland with an appearance similar to cultured cottage cheese.

In another attempt, concentrated lactic acid or hydrochloric acid was added to skim milk at 5 C in a method by McNurlin and Ernstrom in 1962 (34). Milk was heated to 21-26 C without agitation and the curd cooked conventionally. Added rennet improved the body of the curd. Between pH 4.5-5.0, curd firmness increased with decreasing pH and an increasing setting temperature, shortening coagulation time.

A procedure developed by the Iowa State Research Foundation utilizing GDL as the acidogen was reported by Little (33) in 1967. He observed that acid production by GDL could be accelerated by increasing the temperature. An enzyme and curd-former method also was reviewed by Little. Milk was coagulated by enzymes at refrigerated temperature. Higher concentrations of enzyme were required at this low temperature, but the resulting cooked curd was bland and the texture similar to that of the cultured product. The curd-former process consisted of acidifying milk with a food grade acid to a pH of 4.5-4.7. The milk was then pumped through a curd-former which

consisted of small tubes surrounded by warm, circulating water. While rising in the tubes, milk coagulated, whey was expelled and the extruded curd cut by rotating wires. Cooking, washing and draining followed. The total operation required only minutes.

For coagulum formation, Bristol and Martin (7) used phosphoric or phosphoric and citric acids with noncoagulated starter inoculated with 0.05% exponential phase of a commercial culture. A 44% reduction in setting time was reported.

A 1971 U.S. patent by Corbin, (12) utilized an acid mixture, coagulator and acidogen for direct acidification in the manufacture of cottage cheese. The entire process required only 4.5 hrs. Diacetyl, artificial flavors, citric, lactic and phosphoric acids (Vitex 750) were added to milk at 5 C for acidification to pH 4.9-5.0. Heating to 32^{o}C followed, and the acidogen GDL (Vitex 850) was added with Vitex (rennet) coagulator. After an hr, the curd was cut and additional Vitex 750 added to give a pH of 4.4-4.5. Conventional cooking and washing followed. Extended shelf life, improved consistency and 1-1.5% yield increases were reported (18).

White and Ray (52) in 1977 reported a 40% and 33% cut in cooking and cutting times, respectively, utilizing the Corbin method. But, higher yields were reported with the traditional culture method. Sharma et al. (45), however, reported a 6% increase in direct acid set cottage cheese yields at 20% curd solids compared to the cultured method in 1977. A consumer panel preferred the DAS cheese over a cultured product only when an activator butter flavor was added.

A. Composition

The compositional profiles of DAS, acid and sweet wheys are similar (Table 2). Milk contains about 2.5% casein which, upon acidification, is precipitated and retained in the curd (9). The whey proteins or milk serum proteins, primarily lactoglobulin and lactalbumin, constitute 0.6% of milk (44, 9).

Lactose constitutes a higher percentage in DAS whey solids. Lactic acid-producing bacteria use at least 20% of the lactose for acid production. Lactic acid is higher in both acid and DAS wheys than in sweet (rennet) wheys (28).

Calcium and phosphorus are retained in acid whey, while sodium and magnesium remain in the curd (44). However, calcium phosphates are lacking in sweet whey.

B. Uses of DAS Whey in Beverages

The uses of DAS whey in food and beverages has not fully been realized because of FDA regulations and its newness on the market. Demott (15) produced orange and lemon-lime beverages using DAS whey, flavor concentrates, sugar and sodium saccharin. The orange-flavored drink was preferred along with the sweeter samples.

An imitation milk was produced by Chen et al. (10) from 40% neutralized DAS whey, 60% whole milk and added solids. The clarified neutralized whey was blended with the milk and solids before conventional pasteurization and homogenization. Consumers preferred the imitation milk 26% compared to the control at 42% and no preference at 32%.

Table 2. Composition of sweet, acid and DAS wheys.

Whey	Total Solids	Fat	Ash	Protein
		%		
Sweet[a]	6.35	0.50	0.50	0.80
Acid[a]	6.50	~~0.40~~ 0.04	0.80	0.75
DAS[b]	7.25	0.24	0.88	0.70

[a] from Kosikowski (28).

[b] abstracted from Chen's unpublished data, KSU.

III. Cultured Buttermilk

A. Quality Characteristics

Cultured buttermilk results from the souring of skimmilk with select lactic acid and citric acid-fermenting bacteria. Optional ingredients that may be added under the Kansas Regulations for Grade A Pasteurized Milk and Milk Products are "... Grade A dry milk products, concentrated milk products, flavors, sweeteners, stabilizers, emulsifiers, acidifiers, vitamins, minerals and similar ingredients." (27). The product has a clean, acid flavor with pleasant aroma and a viscous, consistent body with little or no whey separation. It is easily digested due to the partial breakdown of lactose and protein by the fermenting bacteria and carries therapeutic value (29).

Homogenized, pasteurized milk is used for culture inoculation. Pasteurization kills bacteria, inactivates lactenin, increases the water holding capacity of proteins and increases the soluble nitrogen for culture growth (25, 35, 51).

Streptococcus cremoris and Streptococcus lactic ferment 18% of the milk's lactose to lactic acid to impart the natural acidic flavor (23). Leuconostoc dextranicum and Leuconostoc cremoris produce diacetyl, acetic and formic acids and carbon dioxide after the pH falls to 5.1. A 1% inoculum requires 14-16 hours of incubation at 21 C to produce a quality buttermilk. The inherent acidity is a natural preservative. Concentrations of flavor volatiles fluctuates with storage.

Although buttermilk is the simplest cultured dairy product to produce, the quality and composition vary more than in any other cultured product (50).

Richter (42), in a 1978 survey, reported that "coarse", "flat" and "lacks flavor" were the major criticisms of cultured buttermilks (Table 3). "Coarse" flavor results from excessive acid production while "flat" and "lacks flavor" usually point to insufficient production of diacetyl and other volatiles. Diacetyl imparts a buttery-nut-meat-like character that can be increased by adding sodium citrate, the precursor of diacetyl and acetoin (49).

Hempenius et al. (24) in 1965 reported that a diacetyl concentration of about 2 ppm was required for maximum consumer acceptability. Psychotrophic bacterial contamination reduced diacetyl concentrations due to diacetyl reductase, and this proceeded faster with increasing storage temperature.

Vasavada and White (49) studied eight commercial buttermilk brands in 1979. Flavor diminished with storage, and panelists could detect diacetyl only in fresh samples, if at all. Although no significant correlation was found, diacetyl to acetaldehyde ratios of 8:1 or greater and diacetyl to acetoin ratios of 6:1 or greater were characteristics or samples receiving highest flavor scores.

Lindsay and Day (32) in 1965 reported a 4:1 ratio of diacetyl to acetaldehyde in mixed strain butter cultures with desirable flavor. At a ratio of 3:1 or lower, a green flavor defect due to acetaldehyde accumulation was pronounced, making the product objectionable.

Richter (42) also reported body and texture defects. These were usually attributable to insufficient SNF and/or stabilizer. For viscosity and stability a SNF of 9% or greater was suggested (48). Gelatin improved

Table 3. Causes of certain off-flavors found in cultured buttermilks.[a]

Flavor defect	Cause
Coarse	Excess lactic acid development and/or diacetyl in relation to other compounds due to slow cooling or long incubation.
Chalky	Use of high heat-treated milk powder and/or excessive heating of vat milk.
Bitter	Excessive acid production by culture causing protein breakdown. Poor cooling, overripening or heat-cool cycles during transportation.
Yeasty	Yeast contamination.
Cheesey	Psychrotrophic contamination.
Slimy or ropy	Psychrotrophic contamination.
Oxidized	Exposure of milk to copper or iron or long light exposure.
Flat	Lack of volatiles, particularly diacetyl and carbon dioxide, inactive starter, high incubation temperature, overripening and unbalanced culture growth.
Burnt	Localized browning during pasteurization.
Grainy	Milk powder, salt or stabilizer undissolved.

[a] from Richter (42) and Vedamuthu (50).

body and appearance by decreasing whey separation in buttermilks (29). Cream at 1-1.8% improved palatability, body and texture.

B. Composition

Wong et al. (53) analyzed four brands of various dairy products including buttermilk (Table 4). Buttermilk contained less fat than whole milk, but had higher sodium concentration due to added salt.

C. Recent Research

Problems that plague cultured cottage cheese processors also surface in production of buttermilk. Excess time and labor are required for culture propagation and for producing the final buttermilk. Lactic cultures have been blamed for producing inconsistent flavors and for slow or low acid development. As a consequence, partial or complete substitution of bacterial acidification by food grade acids (lactic, citric and phosphoric) and GDL has been utilized to overcome these problems with cultures.

Body, texture and flavor stability for a buttermilk produced from 2% SNF and 2% fat skimmilk with GDL and citric acid-fermentating bacteria was reported in 1964 (2). But, the method was lengthy.

Overcast (39) in 1967 reported that acidified buttermilks were consistent in body, texture and flavor as long as acid and flavor additives were standardized for each batch. Increased shelf life and only 30 min required for batch processing also were benefits.

Roberts et al. (43) in 1971 made a pre-acidified cultured buttermilk by lowering initial pH to 5.2 with acid before culture inoculation and

Table 4. Average composition of buttermilk and whole milk.[a]

Milk	Protein	Fat	Solids	Ca	Mg	Na	K	P
	%			mg/100 g				
Whole	3.37	3.41	12.19	113.6	10.0	43.8	148.3	92.6
Buttermilk	3.32	1.20	10.10	107.3	9.9	103.8	134.7	73.1

[a] from Wong et al. (53)

incubation. This produced a more consistent product than regular buttermilk and shortened processing time 2.5-4 hrs.

In a different approach, researchers are including dried and modified wheys in fermented milk beverages to replace skimmilk powder and to supply lactose (16, 28). Bodmershof (26) in Austria, produced a sparkling beverage utilizing 40% sour milk, 50% liquid whey and 10% fruit juice.

IV. Chocolate Drinks

A. Characteristics of Quality Chocolate Drinks

Chocolate is the most popular flavor for flavored milks in the U.S. The name "chocolate milk" is reserved for chocolate milk products which contain at least 3.25% fat. Lowfat chocolate beverages are usually called chocolate drinks or chocolate-flavored drinks. All of these chocolate-flavored beverages represent a small component in the total milk market.

Commercial chocolate flavoring is usually a blend of 1% cocoa, 5-7% sugar, 0.05-1.0% stabilizer and traces of salt and vanillin (21, 29). Quality chocolate drinks have a dark cocoa color, thick, viscous mouthfeel and a rich chocolate flavor. Since cocoa is an expensive ingredient, cheaper chocolate blends have been extended with ground cocoa shells (22). These are coarser and heavier than cocoa, cause excessive sedimentation and contain more bitter and astringent compounds (22).

Usually a Dutch-type cocoa is used for dairy beverages. This name refers to an alkalinization process that renders the cocoa more dispersible, increases the granule swelling, improves flavor and imparts a darker, redder color.

The water soluble gum, carrageenan, the most popular suspending or stabilizing agent in chocolate drinks, is extracted from the red seaweeds (21). A 70% and 30% mix of kappa and lambda carrageenan, respectively, forms weak complexes with the α and β casein in the presence of calcium ions. To a lesser extent the proteins interact with carrageenan's sulfate groups. Both of these reactions cause cocoa particle suspension. This reaction is referred to in the dairy industry as "milk reactivity" (21).

According to Guisley et al. (21), salts may reduce viscosity by reducing the repulsion among the sulfate groups. Meltesen (38), on the other hand, believes that the presence of added salts increases the carageenan gel strength. Increasing concentrations of manganese and magnesium decrease the amount of stabilizers necessary; this relationship is more pronounced with alginates (23).

B. Recent Research

Carob's popularity for extending or substituting for cocoa has surged in the last few years because of increasing cocoa costs. Although carob has a distinctive flavor, it is not detectable at 15-25% cocoa replacement levels in a chocolate drink (22).

Other research centering on extending milk in chocolate drinks with liquid or concentrated wheys has met some success. Edmonson et al. (16) in 1968, utilized a sweet whey concentrate, fresh cream, carrageenan and chocolate flavorings to produce a concentrated sterile milk product with 35% total solids (TS). A sensory panel using a nine-point hedonic scale scored the product (reconstituted to 17.5% TS) 6.5 and a commercial product

6.9. Both products were centrifuged for sedimentation observations. The commercial control averaged 3% by volume and the research sample, 5%. Viscosity increased with storage at 21 C, but it was not considered objectionable by the panelists.

Way-Mil (8), an imitation milk was formulated with sweet or acid whey and vegetable hydrocolloids. The product was bland and suitable for chocolate or fruit flavorings. The whey initially was neutralized to pH 6.7 with NaOH and KOH at a 3:1 ratio. Agitation, clarification and pasteurization followed. Final vacuum treatment removed volatile acids and fermentation products. Water soluble oils were added at 2-3% carrageenan, at 0.01%. This mixture remained in suspension for 3-4 weeks.

Liquid and dried wheys were incorporated into a chocolate drink produced by Vajdi and Perira (48). The liquid whey was neutralized to pH 6.7 with KOH. It constituted 85% of the final product, with whey powder at 8%, stabilizer at 0.05%, sugar at 5% and chocolate at 2%. The mix was high temperature short timed (HTST) pasteurized and then homogenized at 500 and 1500 psi. The experimental chocolate drink and a commercial chocolate drink were evaluated in a six-point paired comparison test, with 1 as excellent. The overall flavor score average of the experimental product was 2.4. No significant difference was found, and flavor scores for the milks were fairly constant over a 30-day storage. Standard plate counts reached 2×10^3 colonies/ml after 30 days; no coliforms were reported.

V. Organoleptic Evaluation

Instruments are used to determine a food's color, texture and caloric content, but sensory procedures employing people are the principal methods for determining food flavor and acceptance. Thus, the testing methods, conditions and environment for sensory testing are controlled to eliminate extraneous variables. All details of method and equipment are standardized for test controls, replication and publication (41).

According to Sidel and Stone (46), the experimental design for sensory evaluations should be developed in advance of any panel sessions. Basically, the design involves a sequence of sample presentations to specific populations. But, objectives, testing environment, judges, response forms and data analysis must all be considered in order that results are unbiased, efficient, and valid estimates of a given population.

Larmond (30) outlined the basic sensory tests which are preference/acceptance, discriminatory or difference and descriptive. Examples are shown in Table 5.

The triangle test is utilized by 66% of the companies involved with sensory evaluation (6). One sample out of three is different in this test, and the panelist has a 33% chance of correct guessing.

Judges may be highly trained, consumers or laboratory personnel (30). Consumers are valuable in gathering test market information, whereas lab panels are useful in initial product formulation and improvement. Highly trained panelists are needed for descriptive methods of determining a food's quality characteristics. Motivation and interest are more important

Table 5. Three sensory test methods and examples.[a]

Method	Examples
Preference/ Acceptance	Paired comparison Hedonic scale Ranking
Discriminatory	Triangle Simple paired comparison Duo-trio Ranking Ratio-scaling
Descriptive	Flavor profile Texture profile

[a] from Larmond (30).

factors for a panelist's performance than age or sex. Being forced to evaluate products that a flavor analyst dislikes can detract from those factors. Panelists should refrain from eating or smoking prior to sessions. Late morning or mid afternoon sessions are preferred (30).

Booths prevent distraction and communication and are recommended for sensory work except for sensory profiles. The area should be quiet, free from foreign odors, comfortable and air conditioned and/or humidity controlled (30). Lighting should be without glare. Colored lighting may be utilized for masking, but judges reactions and tasting abilities under this situation is unknown (30, 46). An alternative is colored cups or black lined cups (30).

Sample preparation methods and formulations must be controlled, sample portions and serving temperatures maintained and reflective of normal eating habits (30). Random three digit numbers are assigned to samples, with presentation order varied (30, 46). Too many samples presented at one sitting may cause fatigue. Usually water, crackers, celery or apples are provided between samples (30, 46).

All data should be statistically analyzed (41).

WHEY-LOWFAT IMITATION BUTTERMILK

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Laboratory Processed Buttermilks

A. Whey-milk Processing

DAS whey at pH 4.20-4.40 was neutralized with laboratory grade magnesium oxide at 0.265 g /100 ml acid whey. The mix was agitated for 15 min with a magnetic stirrer and spin bar, covered and refrigerated for 12-16 hrs for sedimentation. Subsequently, the supernatent was decanted, and the pH adjusted to pH 6.50-6.60 with more DAS whey if necessary.

Formulations of neutralized whey, raw skimmilk, gelatin and NFDM powder were homogenized in a Waring blender, heated at 85 C for 35 min, cooled, inoculated with a lactic acid producing culture and incubated at 21 C.

B. Culture Propagation

Christian Hansen's lactic culture #553 was used for all inoculations and culture propagation was in accordance with Hansen's instructions (Fig. 1, Appendix).

C. Formulations and Organoleptic Evaluations

Formulations were based on varying the following: (a) inoculum rates, (b) ratios of neutralized whey to skimmilk and (c) concentrations of NFDM powder and gelatin. These were tested by seven trained panel members enrolled in the Advanced Food Flavor Analysis class, KSU, which met at 11:30 a.m. three days a week. My study was confined to three weeks and two panels per

session. A preliminary introduction of cultured dairy products including yogurt, sour cream, cottage cheese and cultured buttermilk to the panel laid the groundwork for a cultured buttermilk flavor profile.

The principal consideration to formulations was based on body and mouthfeel characteristics, because few of the panelists like the flavor of buttermilk. The reference buttermilk was prepared from 12% reconstituted NFDM powder inoculated with 1% active lactic culture and incubated for 16 hrs at 21 C.

Through descriptive analysis, discussion and difference testing, a formulation that was as good as or better than the reference was sought. Information obtained from each panel helped in formulating subsequent samples.

All samples were served chilled in coded one-ounce paper cups; quantity was controlled by the use of plastic spoons. Presentation and preparation advice of Larmond was followed (30). Distilled water and crackers were provided. For the difference testing, samples were evaluated in pairs against the reference and then discussed.

D. Analytical Evaluation

Total solids (TS) were monitored by an A.O.A.C. method of drying 1-2 g sample in a tared aluminum dish at 100 C for 3-4 hrs (5).

II. Plant Processed Buttermilks

A. Formulations of Whey-milk

A base formulation of 30% neutralized whey, 70% raw skimmilk, 3% NFDM powder, 0.3% gelatin and cream for a 1% fat level was pasteurized in the KSU Dairy Plant in a 5-gallon steam-jacketed pasteurizer for 35 min at 80 C and homogenized at 1300 psi. Samples were collected in sterile Erlenmeyer flasks, cooled and inoculated with 1.5% active lactic culture. Samples were incubated for 17, 18 and 19 hrs at 21 C. A reference 2% lowfat buttermilk also was processed from 2% raw milk, inoculated with 1% of the active lactic culture and incubated for 16 hrs at 21 C. All samples were refrigerated at 4 C for subsequent analysis.

B. Organoleptic Evaluation

Seven people at Call Hall, KSU, who liked buttermilk, analyzed the whey buttermilks and the reference. Panelists had served on previous panels and three were trained dairy tasters. A triangle taste test with difference tables for analysis were utilized (30). But, the minimum number of panel members required for a significant result were seven.

Panels were conducted on the following samples: two separate runs of 19 hr-incubated whey buttermilks (WBM) stored for three and four days; 17 hr-incubated WBM and control stored for four days; and 18 and 19 hr-incubated WBM stored for seven days.

C. Analytical Evaluation

1. Chemical Analysis

Fat and TS were analyzed to check formulations. Fat was analyzed by

a modified Babcock method utilizing 5 ml of a 50% Roccal solution (50% concentrate of alkyl-dimethyl-benzyl-ammonium chloride) to 200 ml of concentrated sulfuric acid (36). Total solids were monitored as previously mentioned (5). The control and 18 hr-incubated WBM along with a commercial sample were also analyzed by the Animal Sciences and Industry (AS&I) Laboratory for protein, fat, TS, ash and the minerals magnesium, calcium and phosphorus.

Fat was analyzed by the Roese-Gottlieb method and protein, by the Kjeldahl procedure (5). Total solids was obtained by drying a 5 g sample in a tared procelain crucible to dryness at 100 C. This sample was then ignited in a muffle furnace to produce carbon-free ash (5). Ash solutions were prepared for determining Mg, Ca and P concentrations by atomic absorption (5).

2. Gas Chromatography

Gas chromatography of the 17, 18 and 19 hr-incubated WBMs along with the control buttermilk was conducted for volatile flavor compounds after 1, 3, 5 and 10 storage days at 4 C for two trials (2-3 replications per trial).

An Aerograph electrometer model 500 C, an Aerograph oven model 550 B with hydrogen flame detector and a 10 ft x 1/8 in Carbowax 20 M column and a Honeywell recorder were used for sample analysis. Gas rates were: nitrogen at 15.8 ml/min, hydrogen at 23.3 ml/min and oxygen at 140 ml/min.

Analytical techniques followed the head space gas sampling and gas-liquid-chromatographic (GLC) methods of Toan et al. (47). The following

compounds and retention times were monitored: acetaldehyde at 1.6, acetone at 2.4 and diacetyl at 4.2 min.

Standard solutions of acetone, acetaldehyde and diacetyl were prepared in buttermilk. An internal 1-ppm acetone standard was prepared and injected at the beginning and end of each series.

3. pH Values

At 1, 3, 5 and 10 storage days at 4 C, pH values were recorded for buttermilks studied in two trials.

III. Buttermilk Prepared for Consumer Testing

A. Plant Processed Buttermilks

The base formulation of 30% neutralized whey, 70% raw skimmilk, 3% NFDM powder, 0.3 % gelatin and raw cream for a 1% fat level was plant processed. The milk was inoculated with 1.5% active lactic culture and incubated for 18 hrs at 21 C. A reference 1% lowfat buttermilk from skimmilk and cream was also processed and inoculated with 1.5% active lactic culture and incubated for 16 hrs at 21 C.

Whey-milk not intended for consumer testing was incubated for 17 or 19 hrs for further gas chromatographic analysis.

B. Analytical Evaluation

1. Chemical Analysis

The 1% fat reference buttermilk (control) for the consumer test was analyzed at the AS&I laboratory for protein, fat, TS, ash and the minerals Mg, Ca and P.

2. Gas Chromatography

Gas chromatograms of the 17, 18 and 19 hr-incubated WBMs along with the 1% fat control buttermilk were produced at 1, 3, 5 and 10 storage days at 4 C for flavor volatiles as previously described in Section II.

C. Consumer Acceptance

1. Distribution

Samples of the 18 hr-incubated WBM and the 1% fat control buttermilk were collected in sterile eight-ounce yogurt cups. Two coded cups of control and one of the 18 hr-incubated WBM were prepared for a consumer triangle test. The samples were placed in brown bags for distribution to customers of the KSU Dairy Bar purchasing take-home items (Fig. 6, Appendix).

2. Statistical Analysis

Sensory analysis was a combined preference and triangle test reported by Woodward and Schucany (54). This method differentiated those who could detect the odd sample in the triangle test from those who could not and used only the preference data from those discerning panelists. The results were analyzed for statistical difference (25).

3. Cost Analysis

The ingredient cost of one gallon of the whey-lowfat imitation buttermilk and the reference was calculated.

RESULTS AND DISCUSSION

I. Laboratory Processed Buttermilk

The following cultured buttermilk flavor profile was constructed: Buttermilk is a fermented product with a lightly acidic taste with diacetyl and other volatiles contributing to the distinctive aroma. The body is thick and viscous without excessive lumping or whey separation. The body breaks down slowly in the mouth leaving a clean and refreshing aftertaste.

A base inoculum rate of 1.5% was determined optimum for whey buttermilks considered for final formulations. A 1% inoculum rate required over 20 hrs of setting time which was not considered acceptable because of economic constraints; a 2% rate produced excessive lactic acid and whey separation.

A ratio of 3:7 neutralized DAS whey to skimmilk with 2-3% NFDM powder and 0.3% gelatin added was found to show the least difference when compared to the reference (Fig. 2 and Table 6, Appendix). No formulation was found to be close to the reference without those two additives. But both formulations at 2 and 3% NFDM powder were smoother and thinner than the reference. Higher ratios of whey to skimmilk produced excessive whey separation and thinness.

II. Plant Processed Buttermilks

A base formulation including raw cream for a 1% fat level and 3% NFDM powder was developed to improve body, mouthfeel and viscosity. These properties are all vulnerable to homogenization pressures. Extending the

incubation period of 16 hrs by 1-3 hrs gave a firmer body from this formulation.

Using the triangle taste test the following differences were found: 17 differed from 19 hr-incubated WBM ($p < .01$ and $< .05$) for two separate runs; 17 hr WBM from the control ($p < .05$) and for 18 hr from the 19 hr-incubated WBM ($p < .05$). Although not significant, more panelists preferred the following: 19 over 17 hr WBM in one run, 17 hr WBM over control and 18 over 19 hr-incubated WBM.

The gas chromatograph data are in the following section, but preliminary GC trials and the sensory data indicated that the 18 hr WBM should be used for the consumer test.

Fat concentrations of the whey buttermilks were maintained at 1%. The modified Babcock method utilizing a 50% Roccal solution added to the sulfuric acid gave a clearer fat column which was easier to read due to increased protein dispersion. The TS for the whey-milk before inoculation was approximately 12%.

III. Buttermilk Prepared for Consumer Testing

Concentration of fat in the reference buttermilk was reduced to 1% and the inoculum rate increased to 1.5% to minimize product differences.

The composition of the 18 hr WBM was similar to the controls (Table 7). The WBM was higher in protein (gelatin added at 0.3%) than both controls but lower in solids than the 2% control. Fat level for the 1% control was higher than calculated, and this control differed from the 2% control mainly in TS, fat and protein.

Table 7. Composition of controls, commercial and 18 hr-incubated whey buttermilk.[a]

Buttermilks	Composition						
	Total solids	Fat	Protein	Ash	Mg	Ca	P
	%				ppm		
Control - 2% fat	10.13	1.87	2.54	0.78	155	1219	1034
Control - 1% fat	9.58	1.33	2.84	0.80	147	1126	1106
Commercial	8.13	0.66	2.67	0.89	93	1074	925
18 hr-incubated whey	9.91	0.92	2.99	0.85	357	1084	1145

[a] analyzed by AS&I laboratory.

The neutralizing agent, magnesium oxide, increased the ash and magnesium in the WBM. Milk's calcium is retained in the cottage cheese curd, while phosphates are retained in the whey. The commercial brand had added gelatin and salt which probably caused the higher protein and ash levels compared to the 2% control. But, Mg, Ca and P were slightly lower in the commercial brand.

Peak heights obtained by GLC were used to calculate ppm concentrations of diacetyl and acetaldehyde from head space gas sampling and GLC analysis of the buttermilk. Results from these analysis are shown in Tables 8 and 9 and in Figs. 3-5. The control's diacetyl to acetaldehyde ratio was 3.33 after 10-11 storage days compared to 3.28 for the 17 hr, 4.60 for 18 hr and 1.85 for 19 hr-incubated WBM (Table 8). The WBM ratios declined slightly after 3-5 storage days. But, after 10-11 days the 17 hr and 18 hr WBM ratios had increased, while the 19 hr WBM was still decreasing. The control's ratio steadily increased during storage.

Only the 18 hr-incubated WBM reached a 4:1 ratio which according to Lindsay and Day (32) is required for cultured flavor without a green flavor defect (excessive acetaldehyde formation). But no samples (experimental or control) reached a 8:1 ratio which according to Vasavada and White (49) may be important for desired cultured flavor and sensory acceptance.

The control's initial acetaldehyde average was 12.3 ppm compared to 0.94 for 17 hr, 1.07 for 18 hr and 0.91 for 19 hr-incubated WBM (Table 9). Acetaldehyde decreased in all samples with increased storage time; thus, the diacetyl to acetaldehyde ratios increased, although fluctuations were present in all samples. They were more pronounced in 18 and 19 hr-incubated WBM.

Table 8. Diacetyl to acetaldehyde ratios in control and whey buttermilks stored at 4 C for 10-11 days.[a]

Storage days	Buttermilks			
	Control	17 hr	18 hr	19 hr
1[b]	0.05	1.27	1.72	1.50
3[c]	0.82	2.26	4.96	2.81
5[b]	1.70	2.02	3.75	2.39
7[d]	2.12	1.70	3.29	0.82
10-11[b]	3.33	3.28	4.60	1.85

[a] 2-3 replications per trial.

[b] average of 3 trials; [c] average of 2 trials and [d] 1 trial.

Table 9. Acetaldehyde concentrations in control and whey buttermilks stored at 4 C for 10 days.[a]

Storage days	Buttermilks			
	Control	17 hr	18 hr	19 hr
1	12.31	0.94	1.07	0.91
3	0.78	0.61	0.25	0.65
5	0.83	0.75	1.05	1.21
7	0.70	0.80	0.49	0.84
10	0.61	0.59	0.32	0.72

[a] 2-3 replications.

[b] average of 3 trials; [c] average of 2 trials and [d] 1 trial.

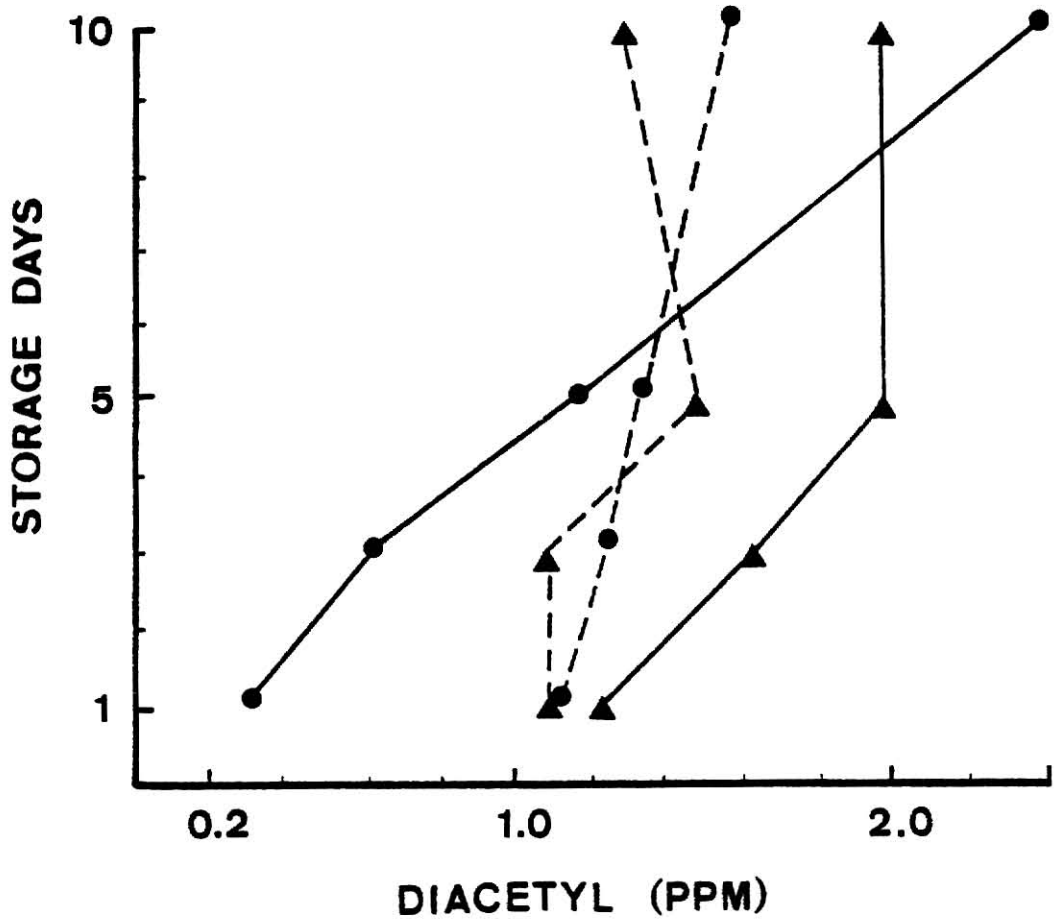


Figure 1. Mean diacetyl concentrations in control and whey lowfat buttermilks incubated at 21°C;
●——● control buttermilk incubated for 16 hrs.
●- - -● whey buttermilk incubated for 17 hrs.
▲——▲ whey buttermilk incubated for 18 hrs.
▲- - -▲ whey buttermilk incubated for 19 hrs.

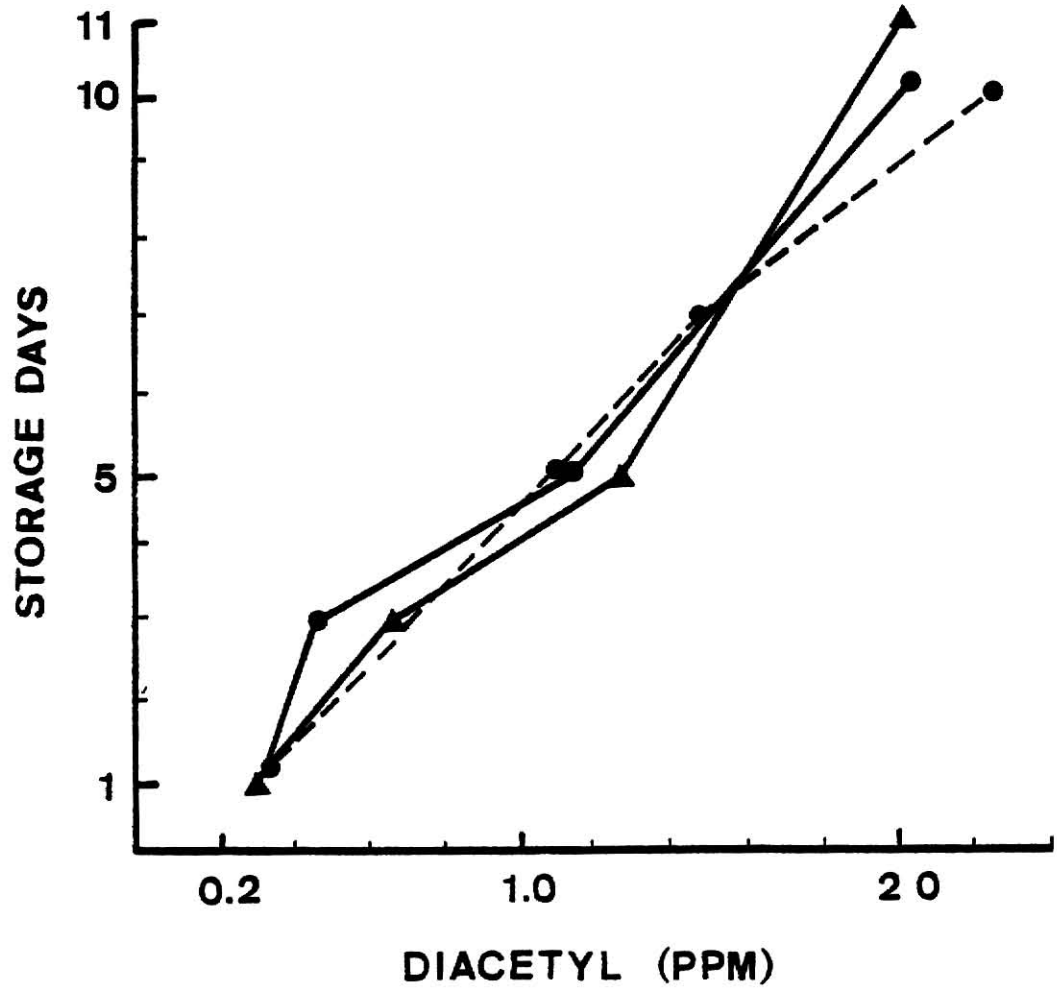


Figure 2. Diacetyl concentrations in buttermilk incubated at 21° C for 16 hrs; ●——● trial 1
●- - -● trial 2
▲——▲ trial 3 (1% fat)

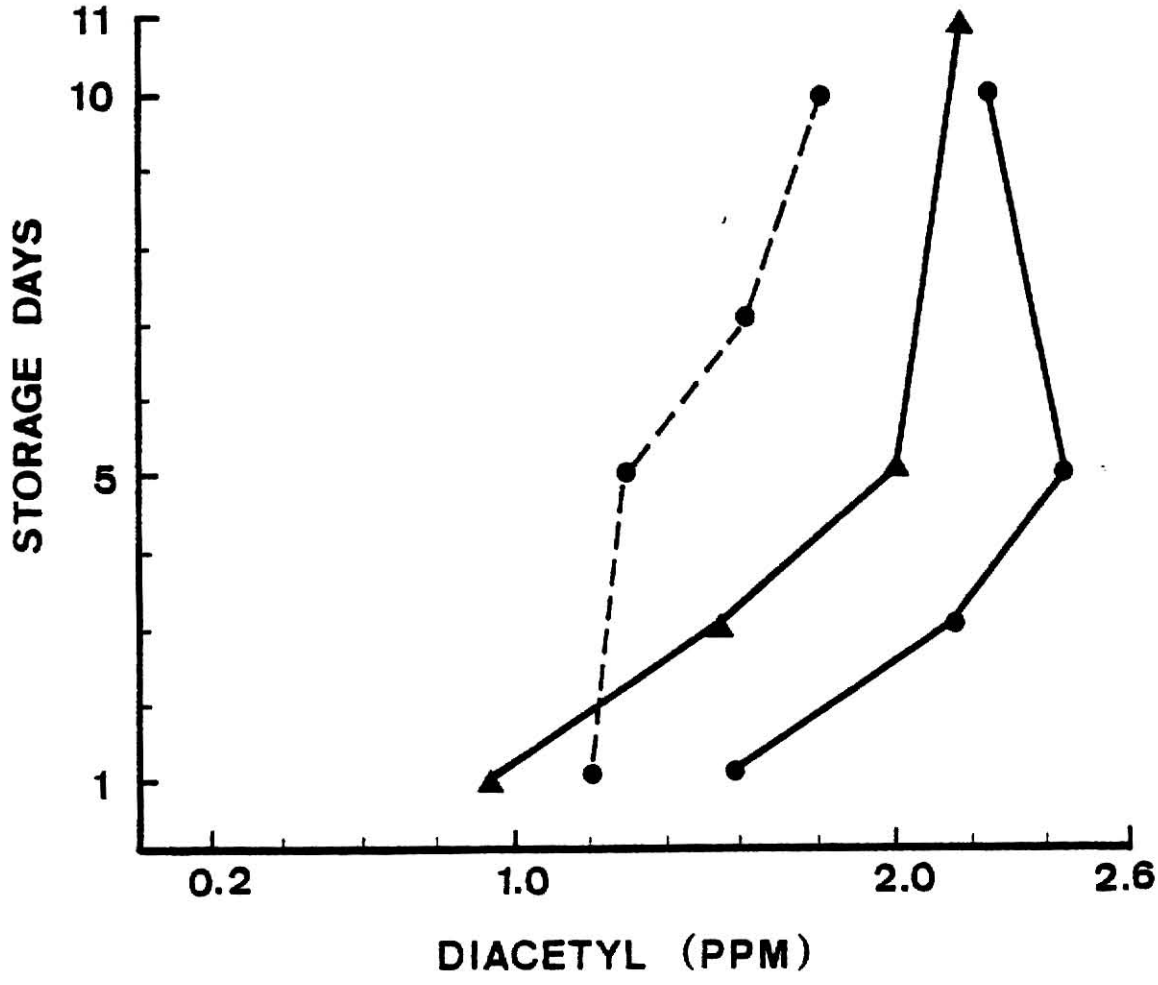


Figure 3. Diacetyl concentrations in whey buttermilk incubated at 21°C for 18 hrs; ●——● trial 1
●- - -● trial 2
▲——▲ trial 3

According to Hempenius et al. (43), about a 2 ppm diacetyl level was required for maximum consumer acceptability in cultured buttermilks; this level was reached for the control and 18 hr WBM after 10 storage days (Fig. 3). The control's value was 2.38; 1.95 for 18 hr, 1.59 for 17 hr and 1.31 ppm for 19 hr-incubated WBMs. Vasavada and White (49) reported decreasing diacetyl concentrations after seven storage days for cultured buttermilks. This does not agree with our data. All WBMs had higher initial diacetyl concentrations than the control, but during the 5-10 storage days while the WBMs increased very little or not at all, the control increased at a linear rate to surpass all WBMs. But no concentration fell to the original level.

Acetone concentrations (Table 10, Appendix) may have increased slightly with the WBMs during storage and more so with the control. However, a high flavor threshold of acetone precludes its contribution to flavor.

Values for diacetyl content in the control milk were more repeatable than those in the WBM (Figs. 4 and 5). The lactic culture used was formulated for milk. A slight deviation from normal milk protein to decreased casein and increased gelatin protein concentrations with subsequent biochemical changes could alter the culture's normal metabolism and consequently its metabolic products. This could be due to pH fluctuations, although only the 19 hr-incubated WBM experienced a large pH deviation (Table 11, Appendix). The whey-milk formulations had a lower initial pH than the fresh skimmilk buttermilk. To reach the pH 5.1 required for initiating maximum citric acid fermentation possible would require less lactic acid accumulation and time.

Thirty-nine consumers responded to a consumer test (Table 12) and results were as follows: 33% preferred the experimental sample (18 hr-incubated WBM), 45.8% the control and 20.8% had no preference (Fig. 7, Appendix). This difference was not significant ($p > .05$) (Fig. 7, Appendix).

They whey-buttermilk cost per gallon was $1.05 compared to the cultured buttermilk at $1.04 (Fig. 8, Appendix). But savings from whey surcharges was not included.

Table 12. Consumer test preferences for whey buttermilk, whey chocolate drink and controls.[a]

Whey product	Preference		
	Whey product	Control	Preference
	%		
Buttermilk	33.3	45.8	20.8
Chocolate Drink	47.1	30.0	22.8

[a] from Woodward and Schucany (54).

WHEY-MILK CHOCOLATE DRINK

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Optimizing Ingredients and Processing Conditions for Laboratory Scale Preparation of the Chocolate Whey-Milk Drink

DAS whey was neutralized to pH 6.60-6.70 with laboratory grade magnesium oxide or a 50% (by weight) potassium hydroxide solution. The pH was adjusted with more DAS whey if necessary.

Formulations containing neutralized whey, raw whole milk, NFDM powder, chocolate mix and sugar were homogenized in a Waring blender for 1 min then heated in a water bath to 80 C for 35 min with constant agitation.

The first formulation was prepared according to the Bowey/Krim-ko Instant Chocolate Drink Preparation No. 315- instructions (Fig. 9, Appendix), with neutralized whey (0.8 ml of 50% KOH/100 ml acid whey), and agitated for 10 min. A blend of four parts whey and six parts whole milk with 1.44% chocolate mix, 4.5% sugar and 0.2% NFDM powder was processed as previously described. A control or reference product using 2% lowfat milk with 1.44% chocolate mix and 4.5% sugar was processed in the same manner. Both were evaluated by twelve trained panel members enrolled in the Food Flavor Analysis class, KSU, who used the triangle test. Data were statistically analyzed (30). Sedimentation also was observed by the author for both samples.

This same base formulation was used to compare the effect of the two neutralizing agents, MgO and KOH, on the chocolate drink's flavor. The MgO was added at 0.265 g /100 ml acid whey, agitated with an electric stirrer and spin bar, covered and refrigerated 12-16 hrs for settling of the mixture.

The 50% KOH solution was also used to neutralize a whey sample, and both formulations were subsequently lab homogenized and pasteurized.

These whey-milk chocolate drinks were analyzed by the AS&I laboratory for fat, protein, TS, ash and the minerals Mg, Ca and P as previously described. Also, they were evaluated by twelve people at Call Hall, KSU, who had served on previous panels utilizing triangle taste testing, and the data were statistically analyzed using the analysis tables of Larmond (30).

For the third formulation, only MgO was used the wheys were neutralized to pH 6.64, 6.80 and 6.90. After allowing the sediment to settle, the clear whey was decanted without disturbing the sediment. The clear whey was mixed with milk and incorporated into the base chocolate formulation and processed. Sedimentation, color and pH after pasteurization were recorded. Total solids were analyzed for two of the samples. Sensory evaluations were not conducted.

II. Plant Homogenization of the Chocolate Drinks

The base formulation previously described with MgO-neutralized whey (pH 6.80) was pasteurized in the KSU Dairy Plant in a 5-gallon steam-jacketed kettle for 35 min at 80 C and homogenized at less than 20 psi. Samples were collected in sterile Erlenmeyer flasks and cooled. The reference product, made with 2% lowfat milk, was processed identically. The chocolate drinks were observed for sedimentation.

III. Institutional Blender-Homogenization of the Chocolate Drinks

The base formulation with MgO-neutralized whey (pH 6.80) and a reference were heated to 80 C in a steam-flowing sterilizer, homogenized in an

institutional Waring blender for 2 min and then reheated to 80 C for 35 min and cooled. Samples were examined for sedimentation by observing a 50 ml samples in a graduated glass cylinder after 5 days at refrigeration temperature. Additional 15 ml samples were centrifuged for 10 min in graduated tubes and sediment volumes measured.

The experimental and control samples were analyzed by the author for protein, fat, TS and ash. Protein was analyzed by the Kjeldahl method, fat by the modified Babcock method utilizing the 50% Roccal solution, solids by oven drying and ash by incinerating at 550 C (5, 36).

These samples were analyzed for coliforms on violet red bile (VRB) agar (36). Standard plate counts (SPC) were conducted after 1, 3, 5 and 10 storage days at 4 C following Standard Methods (36).

IV. Consumer Testing of the Chocolate Drinks

A. Institutional Blender Process

The base formulation using MgO-neutralized whey (pH 6.80) and the reference (2% lowfat milk) were processed by the institutional Waring blender-homogenization method previously described.

B. Consumer Acceptance

1. Distribution

The chocolate milk drinks were transferred to sterile eight-ounce yogurt cups for a consumer sensory test: two coded controls, and one of the whey chocolate drink. The cup lids were slit and taped for subsequent

straw insertion and placed in brown bags for distribution to customers of the KSU Dairy Bar. Cups were taped closed also to prevent tasters from seeing a slight color difference of the two milks (Fig. 10, Appendix).

2. Statistical Analysis

Sensory analysis was a combined triangle/preference test reported by Woodward and Schucany (54). The results were analyzed for statistical difference (25).

3. Cost Analysis

The ingredient cost of one gallon of whey-milk chocolate drink was compared to a chocolate milk drink.

RESULTS AND DISCUSSION

I. Optimizing Ingredients and Processing Conditions for Laboratory Scale Preparation of the Chocolate Whey-Milk Drink

Analysis of the triangle taste test results indicated no significant difference in the organoleptic properties of the whey and control-chocolate drinks. The twelve member flavor profile found that viscosity, color, uniformity and smoothness were important quality characteristics of a pleasing chocolate drink. Two noted that the whey chocolate drink was darker than the control. The whey drink had a "watery layer" at the surface and a chocolate sediment on the bottom of the Erlenmeyer flask after five days. The control also had both of these layers in less amounts. The depth of the "watery layer" and amount of sediment were not quantitated at this time. Upon shaking, the "watery layer" and sediment redispersed.

There was no significant flavor difference ($p < 0.05$) between the drinks utilizing whey neutralized with MgO or KOH. A saltier taste with the KOH-neutralized samples were noted by two trained dairy panelists. Analytically, the MgO-neutralized sample had about three times as much Mg as the KOH-neutralized sample (Table 13). Both were comparable in fat, protein and TS.

The pH of the chocolate drink containing a pH 6.90 whey dropped to 6.70 after pasteurization and had the least sediment (4.4%) after 16 days (Table 14). A formulation with a post-pasteurization pH of 6.67 (whey at pH 6.80) had a 7% sediment after 16 days, and the whey drink with a final pH of 6.56 had 12%. Thus, the lower the pH of the whey the more sediment on storage. The color of all three formulations stuided was darker than the control. This difference was not masked under red lighting. A chocolate

Table 13. Composition of chocolate-whey milk drinks utilizing MgO or KOH as whey-neutralizing agent.[a]

Chocolate whey-drink	Composition						
	Total solids	Fat	Protein	Ash	Ca	Mg	P
	%				ppm		
MgO whey	16.6	2.2	2.9	0.98	940	442	1412
KOH whey	16.4	2.2	3.0	1.10	1021	177	1413

[a] from AS&I laboratory

Table 14. Sedimentation rates of 3 chocolate drinks containing whey neutralized to various pH values.

Initial whey pH	Chocolate drink pH	Sediment rates	
		7 days	16 days
		%	
6.90	6.70	4	4.4
6.80	6.67	4	7.0
6.64	6.56	10	12.0

drink made with acid whey rather than neutralized whey was the closest in color to the control but had a post-pasteurization pH of only 5.68. The neutralizing agents were possible causative agents either directly or indirectly of the darker color whey chocolate drinks. The whey for all subsequent base formulations was at pH 6.80.

II. Plant Homogenization of the Chocolate Drinks

The whey and control chocolate drinks yielded sedimentation immediately after low pressure homogenization of the pasteurized products. The whey drink was lighter in color than the control due to inadequate suspension of the cocoa particles, which may have been caused by a lesser effect of the carrageenan and a low "milk reactivity" reaction between the proteins and sulfate groups of milk and the gum with the reduced milk protein content in the whey drink.

III. Institutional Blender-Homogenization of the Chocolate Drinks

After seven days at 4 C, the control had no sedimentation or watery layer while the whey drink had a slight water layer at 4% (by volume) but no cocoa sedimentation. After 10 days, the "watery later" in the whey drink increased to 4.5%, and the control, while not having a "watery layer", possessed a 7% (by volume) of cocoa sedimentation and the whey a 4% cocoa sedimentation. By centrifuging the samples in graduated centrifuge tubes, sedimentation was enhanced. The amount of sediment was 5.3% for both samples, however the control's floculum was compact while the whey's was fluffier. This data is similar to Edmonson's data (16) for a whey chocolate drink

which was centrifuged for sedimentation and had a 5% sediment (by volume) compared to a control chocolate drink's of 3%, but conditions employed for this experiment were not reported.

The viscosity after 10 days' storage at $4^{o}C$ was 26-27 centipoises (cps) for both samples (Table 15). However, maximum viscosities were reached after 5-6 days; 47 cps for the whey drink and 49 for the control. Thus, sedimentation increased slightly and viscosity decreased over 5-10 days of storage. The whey drink's viscosity decreased while its "watery layer" increased.

Meltesen (38) reported that for the Bowey/Krim-ko chocolate mix, viscosity is at a maximum 24-36 hrs after processing, and remains constant until bacteria begin to lower the pH which subsequently lowers the gel strength. The viscosity of the samples is mostly due to carrageenan and the alkalization of the cocoa. Interaction of electrical charges on the protein cause cocoa particle suspension. But other solutes can alter this relationship; for example, increased salts lower the viscosity by reducing electrostatic repulsion (21). Meltesen (38), on the other hand, believes that salts would increase viscosity and the higher salt content of a whey-milk would aid in viscosity and gel formation.

The pH of both control and whey-milk chocolate drinks fluctuated little over 10 days (Table 16, Appendix). The SPC counts did not point to excessive bacterial build-up. Initial counts (colonies/ml) were 1.5×10^{2}/ml and 1.3×10^{2}/ml for the whey and control respectively, but after 3-5 days the former reached 8.5×10^{1}/ml and 1.25×10^{2}/ml and the control 1.41×10^{2}/ml and 1.0×10^{2}/ml. Coliforms were present for both samples in the 1-2.5 x

Table 15. Viscosity of control and chocolate whey-drinks.[a]

Storage days	Viscosity	
	Control	Whey
	cps	
1-2	41	45
5-6	49	47
7-8	44	37
9-10	27	26

[a] from 1 trial with Brookfield Viscometer, #2 spindle and 60 rpm.

10^1/ml colony range. But, excessive bacteria were not present which could cause acid build-up, a pH drop and a weakening of the gel.

The whey contained less fat, protein and TS than the control (Table 17).

IV. Consumer Testing of the Chocolate Drinks

For a consumer test, 37 panelists participated. The results were: 47.1% preferred the whey drink, 30.0% the control and 20.8% had no preference (Table 12). The differences observed were not significant ($p \geq 0.05$) and calculations are given in Fig. 7 in Appendix.

The whey-milk chocolate drink ingredient cost per gallon was $1.07 compared to a chocolate milk drink at $1.26. But, savings from whey sewer surcharges were not included (Fig. 11, Appendix).

Table 17. Composition of control and whey-chocolate drinks.

Chocolate drink	Composition			
	Fat	Protein	Total Solids	Ash
	%			
Whey[a]	1.8	2.42	14.76	0.62
Control[a]	2.1	3.58	16.14	0.69
Whey[b]	2.0	2.56	15.04	0.81
Control[b]	2.4	3.35	16.27	0.79

[a] from laboratory analysis by author.

[b] from AS&I laboratory.

CONCLUSIONS

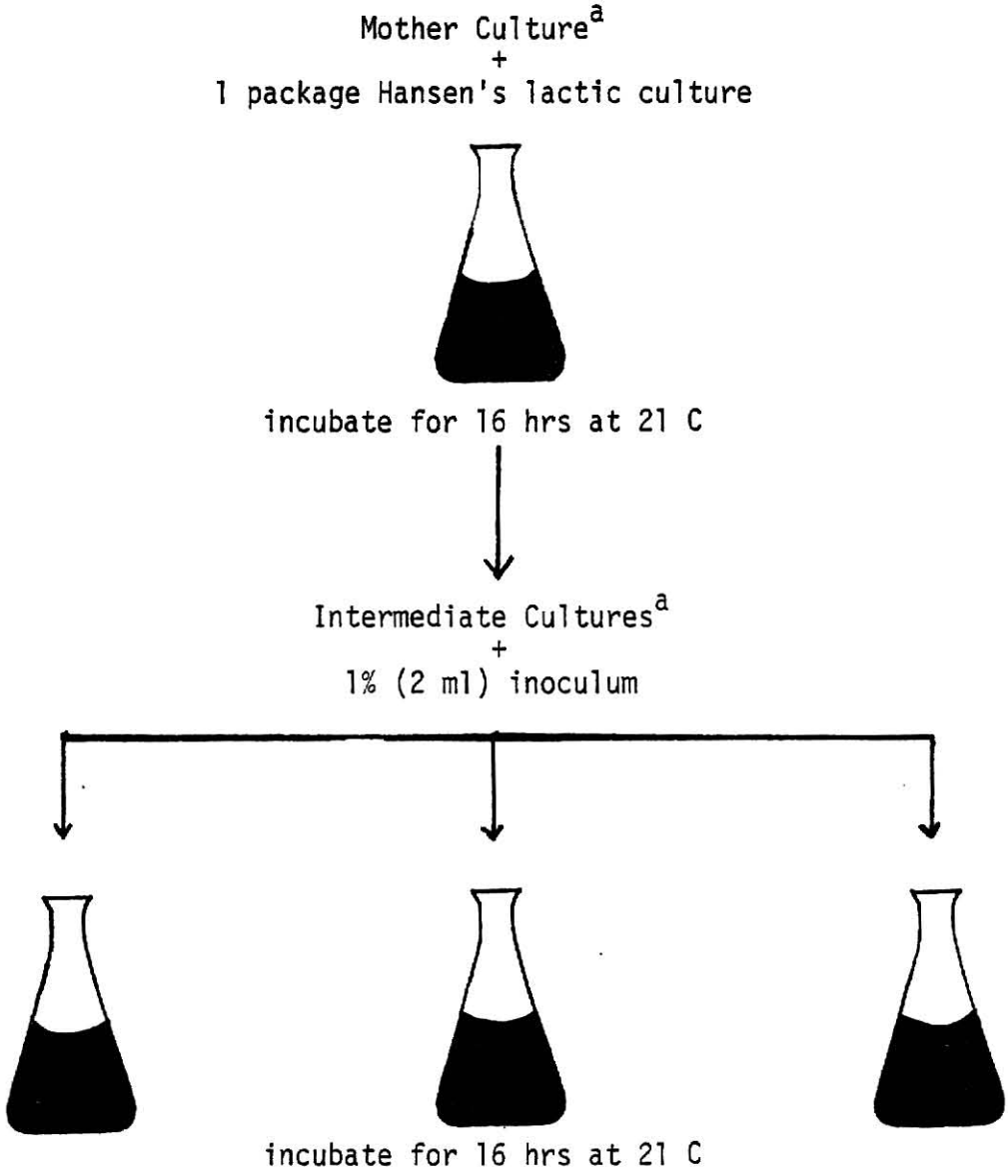
The following conclusions have been drawn from data obtained in this study:

1) Neutralized whey can partially substitute for skimmilk in buttermilk and for whole milk in a chocolate-flavored drink.
2) Whey-buttermilk can be plant processed using a 5-gal kettle pasteurizer and a one-stage homogenizer.
3) Whey-chocolate drink can be pasteurized and homogenized using an institutional blender on a small scale, and could probably be plant processed following the Bowey/Krim-ko instructions.
4) Both products were compositionally similar to their references, but had higher Mg levels due to the whey neutralizing agent magnesium oxide, and the whey-buttermilk had higher protein due to added gelatin.
5) Ingredient cost for the whey-chocolate drink was lower than for the control, while the whey-buttermilk cost was slightly higher than its control.
6) No significant differences were found in acceptability between the whey and conventional products.

APPENDIX

Fig. 1

Inoculation Flow Chart



[a] Each culture media flask contains 200 ml reconstituted nonfat dry milk powder that has been heated at 85-90 C for 45 min

Christian Hansen's Laboratory, Inc.
9015 West Maple Street
P.O. Box 14397
Milwaukee, Wisconsin 53214

Fig. 2

Name _____

Date _____

Buttermilk Evaluation

Directions: Compare the BODY and MOUTHFEEL of the coded samples with those of the reference and indicate "relative difference" by checking the appropriate blanks.

Sample _____

DIFFERENCE		COMMENTS
Body		
Great	___	_____
Moderate	___	
Slight	___	_____
Very Slight	___	
No Difference	___	_____
Mouthfeel		
Great	___	_____
Moderate	___	
Slight	___	_____
Very Slight	___	
No Difference	___	_____

Sample _____

Body		
Great	___	_____
Moderate	___	
Slight	___	_____
Very Slight	___	
No Difference	___	_____
Mouthfeel		
Great	___	_____
Moderate	___	
Slight	___	_____
Very Slight	___	
No Difference	___	_____

Table 6. Formulations for whey-lowfat imitation buttermilk

Neutralized whey to skimmilk	NFDM powder added %	Gelatin added %	Incubation hrs
5:5	1	0	20
4:6	1	0	20
4:6	2	0	18
5:5	2	0	18
4:6	2	0	20
4:6	3	0.2	16
4:6	2	0.2	16
4:6	3	0.4	16
4:6	2	0.3	16
3:7	3	0.2	16
4:6	3	0.3	16
4:6	3	0.4	16
4:6	2	0.5	16
4:6	3	0.5	16
3:7	2	0.3	16
3:7	3	0.3	16
3:7	3	0.4	16

Table 10. Average acetone levels in control and whey buttermilks stored at 4 C for 10 days.[a]

Storage days	Buttermilks			
	Control	17 hr	18 hr	19 hr
	ppm			
1	0.86	0.81	0.78	0.78
3	0.88	0.98	0.71	0.81
5	0.92	0.70	0.70	0.78
10	1.04	0.83	0.77	0.78

[a] from average of 2 trials (2-3 replicates per trial).

Table 11. Average pH values of control and whey buttermilks stored at 4 C for 10 days.[a]

Storage days	Buttermilks			
	Control	17 hr	18 hr	19 hr
	ppm			
1	4.70	4.69	4.70	4.69
3-4	4.60	4.65	4.68	4.74
5-6	4.69	4.71	4.76	4.14
10-11	4.72	4.75	4.81	3.92

[a] from average of 2 trials

Fig. 6

BUTTERMILK EVALUATION

Taster _____

There are three buttermilk samples in the bag you received. One of the samples is different from the other two. (Please shake each of the buttermilk containers before tasting.)

1. Circle the buttermilk sample you believe to be the different sample.

_____ _____ _____

2. Which sample or samples do you prefer?

odd sample identical samples no preference

_____

Fig. 7

Calcuations for Statistical Analysis of Buttermilks and Chocolate Drinks

The following calculations were performed on the combined triangle and preference test according to Woodward and Schucanny (52).

	Prefer A	Prefer B	No Preference	
Correct (selected odd sample in triangle test)	n_1	n_2	n_3	n.
Incorrect (did not select odd sample)	n_4		n_5	n.

$$\hat{p}_A = \frac{4(n_1) - (n_4)}{2(3n. - n)} \; ; \qquad \hat{p}_B = \frac{4(n_2) - (n_4)}{2(3n. - n)} \; ; \qquad \hat{p}_{NP} = \frac{2(n_3)-(n_5)}{(3n. - (n)}$$

A. For buttermilk consumer panel, the following estimators were found:

$\hat{p}_{whey} = .333$; $\hat{p}_{control} = .458$ and $\hat{p}_{NP} = .208$

$n_1 = 10$; $n_2 = 13$; $n_3 = 6$; $n_4 = 8$; $n_5 = 2$; $n = 39$ and $n. = 29$

B. For chocolate drink consumer panel, the following estimators were found:

$\hat{p}_{whey} = .471$; $\hat{p}_{control} = .3$ and $\hat{p}_{NP} = .228$

$n_1 = 11$; $n_2 = 8$; $n_3 = 5$; $n_4 = 11$; $n_5 = 2$; $n = 37$ and $n. = 24$

Calculations for determining the 95% confidence interval differences in $Q_1 - Q_2$ for the consumer buttermilk and chocolate drinks

$$\hat{q}_1 = \frac{n_1}{n} \; ; \qquad \hat{q}_2 = \frac{n_2}{n} \; ; \qquad \hat{q} = \frac{n_1 + n_2}{2n}$$

$$(\hat{q}_1 - \hat{q}_2) \pm 1.96 \times \sqrt{\frac{\hat{q}_1 \times (1-\hat{q}_1) + \hat{q}_2 \times (1-\hat{q}_2) + 2\,(\hat{q}_1 \times \hat{q}_2)}{n}}$$

A. For the buttermilk consumer panel, the interval - .077 $\pm$ .2397 was found.

B. For the chocolate drinks consumer panel, the interval .081 $\pm$ .2291 was found.

Fig. 8

Comparative costs of producing one gallon of 1% fat whey lowfat buttermilk and 1% fat cultured buttermilk

Ingredient	Cost	
	Whey BM	Conventional BM
Acid whey	0	--
Magnesium oxide @ $1/lb	0.07	--
Skimmilk @ 8¢/lb	0.48	0.69
NFDM powder @ 90¢/lb	0.23	0.23
Gelatin @ 1¢/gm	0.15	--
Cream @ $1.45/lb	0.12	0.12
	$ 1.05	$ 1.04

Fig. 9

Granex Agglomerated Press Instant Chocolate Flavored
Dairy Preparation No. 315

Ingredients - Cocoa (processed with alkali), sugar, salt, carageenan and vanillin (artifical flavoring)

Mix Instructions

1) Add 16 lbs Granex 315 and 50 lbs sugar to 100 gallons of milk in vat. Disperse.

2) Vat process - Heat to 170 F with constant agitation. Hold for 30 minutes.

   Short time - process through HTST at 175-180 F at reduced pump speed. In most cases, normal pump speed is satisfactory, however, if settling occurs reduce 50%.

3) Cool to 40-45 F and bottle; Chocolate should not be agitated after cooling.

Milk of any butterfat may be used but we recommend at least 2% for best results.

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[1] Bowey/Krim-ko, Inc.
Indianapolis, Indiana 46241

Table 16. Average pH values of control and whey chocolate drinks stored at 4 C for 12 days.[a]

Storage Days	Chocolate Drink	
	Whey	Control
	pH	
1	6.67	6.71
3	6.67	6.70
5	6.73	6.72
8	6.88	6.88
12	6.83	6.75

[a] from 1 trial.

Fig. 10

CHOCOLATE DRINK EVALUATION

Taster _____

There are three chocolate drink samples in the bag you received. Two of the samples are identical and one is different.

INSTRUCTIONS:

- Shake the carton.
- Remove tape from the straw hole and insert straw.
- Taste each sample in the order under Question 1.

1. Circle the chocolate drink you believe to be the different sample.

_____ _____ _____

2. Which sample or samples do you prefer?

different identical no preference

Please write your address below if you would care to receive the survey results. Thanks!

Fig. 11

Comparative costs of producing one gallon of whey chocolate drink and chocolate milk drink.

Ingredient	Cost	
	Whey BM	Conventional BM
Acid whey	0	--
Magnesium oxide @ $1/lb	0.07	--
Whole milk @ 13¢/lb	0.67	--
2% milk @ 11¢/lb	--	0.95
Chocolate mix @ $1.64/lb	0.20	0.20
Sugar @ 27¢/lb	0.11	0.11
NFDM powder @ 90¢/lb	0.02	--
	$ 1.07	$ 1.26

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DIRECT ACID SET COTTAGE CHEESE WHEY AS AN EXTENDER FOR BUTTERMILK AND CHOCOLATE MILK DRINKS

by

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B.S., University of Texas, Austin, Texas, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

Neutralized direct-acid-set whey was substituted for skimmilk at three parts whey to seven parts skim in a 1% lowfat whey buttermilk drink and for whole milk at four parts whey to six parts of milk in a chocolate whey drink.

The whey-buttermilk drink included added cream, non-fat-dry milk (NFDM) powder and gelatin. This mix was pasteurized, homogenized, cooled and incubated for 18 hrs after adding 1.5% active lactic culture. After 10 storage days at 4 C, this product had a 1.9 ppm diacetyl concentration and a 4.6 ratio of diacetyl to acetaldehyde.

Whey-milk with added NDFM powder for the chocolate drink was initially heated to pasteurization temperature, homogenized in an institutional blender and then pasteurized. The viscosity of this product remained stable until 5-10 storage days at 4 C.

Products were evaluated separately by consumers at the KSU Dairy Bar, using a combined preference/triangle test. Of the buttermilk drinkers, 33% preferred the experimental, 45% a control and 21% had no preference. For the chocolate drinks, 47% preferred the experimental whey chocolate drink, 30% a control and 23% had no preference. These differences were not significant ($p \succ 0.05$).

Calculated ingredient cost of the whey-buttermilk drink is $1.05/gallon compared to $1.04 for conventional buttermilk. The cost of the whey-chocolate drink is $1.07/gallon compared to $1.26 for conventional chocolate drink.