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INVESTIGATIVE STUDY OF THE DEVELOPMENT OF A DRY WHOLE MILK SUBSTITUTE FOR RATION USE

PET, INCORPORATED

PREPARED FOR
ARMY NATICK LABORATORIES

DECEMBER 1974

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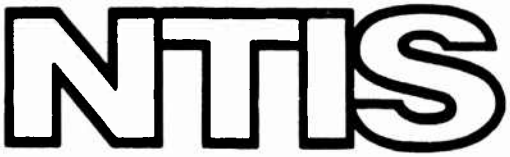

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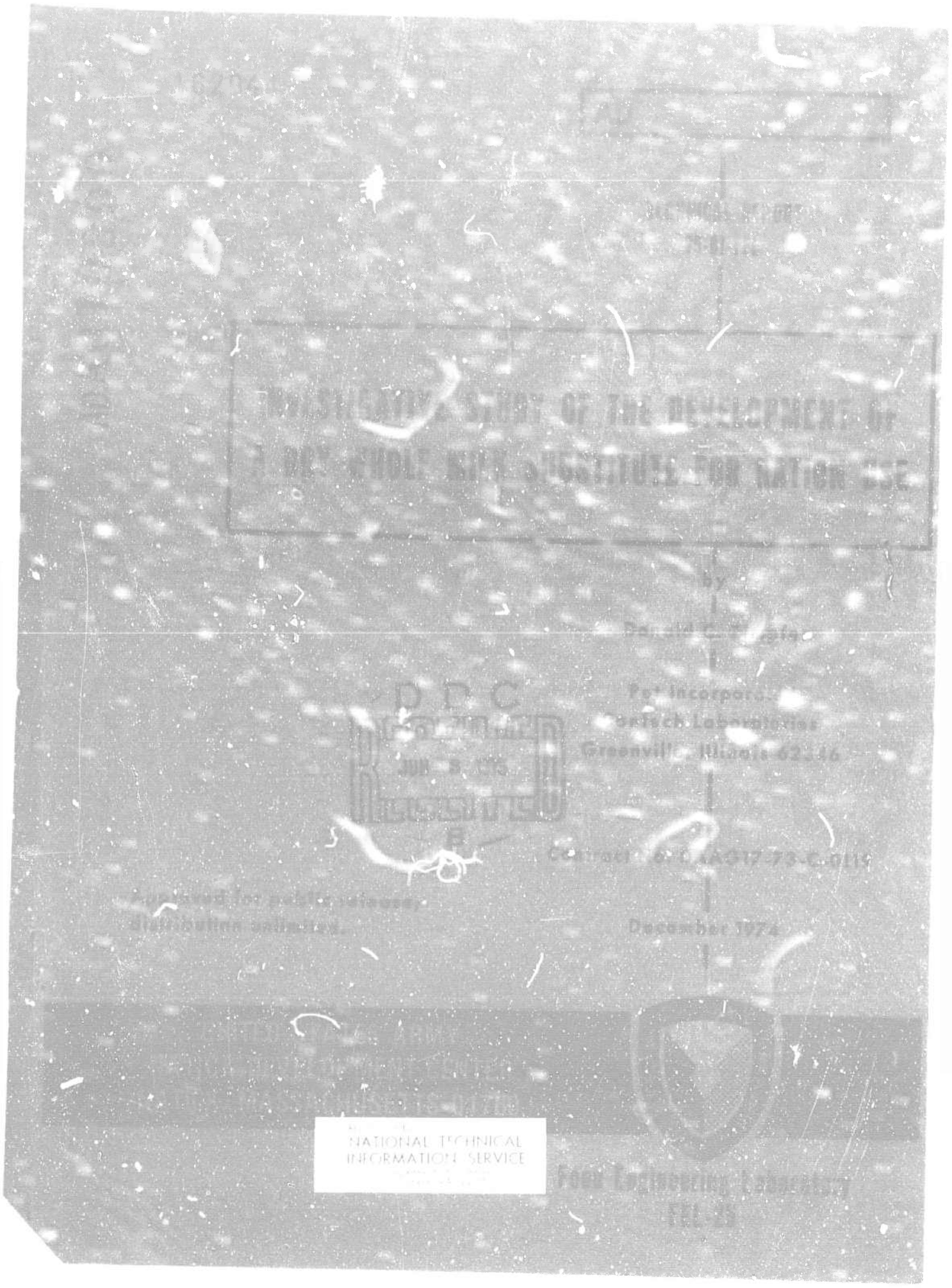

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DEVELOPMENT	BEVERAGES	REHYDRATION
MILK	MILITARY RATIONS	STORAGE
DRIED FOODS	RATIONS	MILK FAT
SUBSTITUTES	WHOLE MILK	DRYING
CHALKINESS	VEGETABLE OIL	MEAL, READY TO EAT, INDIVIDUAL

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A dry whole milk substitute for ration use was developed. This investigative study involved the selection and evaluation of formulation variations, processing parameters, and instantizing conditions as they affect the physical and flavor characteristics of the product. The historic problems of a chalky mouth sensation and very limited shelf life were overcome.

Chemical, physical and organoleptic methods were used to evaluate product

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quality.

A specific formulation and process are proposed.

SUMMARY

This experimental program utilized raw skim milk, modified vegetable oil, and other additives together with optimized processing conditions to produce a substitute for dry whole milk which met specific storage, rehydration and acceptability requirements. Compositional variables involved amount and type of vegetable oil, emulsifier, lecithin, wetting agent, seed lactose, antioxidant, silicon dioxide, and flavorings. Processing variables were concentrating, homogenizing, spray drying, instantizing, and packaging. All experimental samples were evaluated by an expert panel for flavor, amount of foam and chalkiness after rehydration under controlled conditions.

When processing conditions were tentatively established representative samples were sealed under vacuum in oxygen impermeable pouches for storage at 18, 28, and 38°C. A number of experimental products were stored in oxygen scavenger pouches. In addition to monthly observations by an expert panel, stored products were evaluated at 0, 3, 6, and 9 months by a panel of male college students. The following test data were also recorded for initial and stored products: moisture, fat extractable with petroleum ether, rehydration rate, undissolved solids, homogenization efficiency, and evidence of caking, browning and oxidation. Initial values were also recorded for total fat, protein, ash, iodine value of fat and PER.

There was no evidence of browning, oxidative deterioration or change in moisture content in any of the experimental samples during 9 months of storage at 18, 28 and 38°C. Likewise all stored products reconstituted in less than 5 minutes with no evidence of chalkiness. All products exhibited excessive foam. Items stored for 9 months at 28°C and 6 months at 38°C showed moderately hard caking which did not interfere with reconstitution.

As evaluated by the expert panel, most samples stored at 18 and 28°C remained acceptable throughout 9 months storage. At 38°C, however, deterioration was evident after 6 months. Using fresh 2% market milk as a standard the student panel rated all reconstituted products as inferior. After 6 months, products stored at 38°C were definitely inferior to those held at 18 and 28°C. No significant advantage was noted for products stored in oxygen scavenger pouches.

Based on products consistantly showing the best rating after storage, recommendations are made regarding procedures for concentrating, incorporating vegetable oil with emulsifier and antioxidant, vacuum treating, homogenizing, spray drying, adding seed lactose and silicon dioxide prior to instantizing with water containing a wetting agent and lecithin, and redrying to 3% moisture. Amounts of all additives are stated for the final product containing 3% moisture.

FOREWORD

Beverage milk has consistently been rated among the most popular foods supplied to the Armed Forces. Unfortunately, attempts to develop dry whole milk suitable for use in operational rations, for example, Meal, Combat, Individual, have not been successful, notwithstanding a vigorous research and development program throughout the 1950's. As projected for use in such a ration, the dry product must be acceptable after rehydration by simply stirring with ambient temperature water in a canteen cup. Experience with dry whole milk revealed poor acceptability due, in part, to a chalky flavor on rehydration. In addition, the dry product failed to withstand more than a few months storage at 38°C. This investigation was motivated by the possibility that replacement of milk fat with a modified vegetable oil, combined with advances in drying technology, would result in a product of adequate storage stability and which, on rehydration, would yield an acceptably substitute for beverage milk.

This experimental program was performed at the Contech Laboratories of Pet Incorporated, Greenville, Illinois 62246 with funds from Project Number 1J662713A034, title: Food Technology, Technical Area AH99B, Subsistence Technology, Technical Effort AH99BB, Food Processing and Preservation Techniques. Mr. Donald C. Zimpfer of Pet Incorporated served as Principal Investigator under the general guidance of Dr. John J. Betscher, Manager, Contract Research for Pet Incorporated. Drs. Maxwell C. Brockmann and Herbert A. Hollender served as Project Officer and Alternate Project Officer, respectively, for the US Army Natick Development Center.

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INTRODUCTION

THE OBJECTIVE OF THIS INVESTIGATION WAS TO DEVELOP A DRY MILK PRODUCT WHICH, AFTER CONTROLLED STORAGE, WOULD READILY HYDRATE TO YIELD A BEVERAGE HAVING NUTRITIONAL CHARACTERISTICS OF FRESH MILK AND AN ACCEPTABILITY ADEQUATE TO QUALIFY AS A SUBSTITUTE FOR FRESH WHOLE MILK IN RATION USE.

ALL COMPONENTS OF THE DEVELOPED PRODUCT SHOULD CONFORM TO FDA REQUIREMENTS FOR HUMAN CONSUMPTION WITH THE PROTEIN COMPONENT ORIGINATING OR BEING DERIVED FROM MILK. THE DRY PRODUCT SHOULD HYDRATE FULLY IN LESS THAN FIVE MINUTES WHEN DISPERSED IN WATER AT 16-20°C BY MANUAL AGITATION WITH A SPOON OF APPROPRIATE SIZE. THE PRODUCT SHOULD BE FULLY HYDRATED, FREE OF CHALKINESS, AND SHOULD UNDERGO NO CHANGE WHEN EXAMINED 30-35 MINUTES AFTER CONTACT WITH WATER. THESE ASSESSMENTS WERE TO BE MADE BY THREE QUALIFIED JUDGES OF MILK PRODUCTS.

HYDRATED PRODUCT SHOULD HAVE A PROTEIN EFFICIENCY RATIO (PER) EQUAL TO FRESH MILK, A MINIMUM FAT CONTENT OF 2.0% AS RECONSTITUTED, AND A CALORIC LEVEL CORRESPONDING TO FLUID MILK AT THE SAME FAT CONTENT. REPRESENTATIVE SAMPLES SHOULD BE PACKAGED IN SEALED POUCHES IMPERMEABLE TO OXYGEN AND MOISTURE AND BE EVACUATED TO A DIFFERENTIAL PRESSURE OF APPROXIMATELY ONE ATMOSPHERE. PRODUCT THUSLY PACKAGED SHOULD BE STORED CONCURRENTLY AT 18, 28, AND 38°C.

PRODUCT SHOULD BE EVALUATED PRIOR TO THE STORAGE AND AFTER 3, 6, AND 9 MONTHS' STORAGE AT 18, 28, AND 38°C. PRODUCT STORED FOR SIX MONTHS AT 38°C AND FOR NINE MONTHS AT 18 AND 28°C SHOULD RECEIVE HEDONIC SCALE RATINGS OF FIVE OR ABOVE WHEN SUBMITTED TO THREE QUALIFIED JUDGES OF MILK WITHIN FIVE TO TEN MINUTES AFTER CONTACT WITH WATER. ADDITIONALLY, AFTER DISPERSION AND HYDRATION PRODUCT SHOULD BE RATED FOR OVERALL ACCEPTABILITY WITHIN 30 MINUTES AFTER CONTACT WITH WATER. SAMPLES SHOULD BE RATED AT 16-20°C ON A NINE-POINT SCALE BY A PANEL OF YOUNG ADULT MALES WHO NORMALLY CONSUME FRESH WHOLE MILK. FRESH WHOLE MILK OF A COMPARABLE FAT CONTENT SHOULD ALSO BE INCLUDED IN THIS PANEL FOR COMPARATIVE PURPOSES.

THE FOLLOWING ANALYTICAL DATA SHOULD BE PROVIDED FOR HYDRATED TEST PRODUCT AFTER REFERENCE STORAGE PERIODS AND FOR REFERENCE SAMPLES OF FRESH MILK.

WATER - PERCENT BY WEIGHT
FAT - PERCENT BY WEIGHT
INSOLUBLE NONFAT SOLIDS - PERCENT BY WEIGHT

THE FOLLOWING DETERMINATIONS SHALL BE PERFORMED ON THE DRY EXPERIMENTAL PRODUCT AT THE REFERENCE STORAGE PERIODS.

MOISTURE
FAT (INITIAL PRODUCT ONLY)
PROTEIN (INITIAL PRODUCT ONLY)
ASH (INITIAL PRODUCT ONLY)
FAT EXTRACTED WITH PETROLEUM ETHER
IODINE VALUE OF FAT (INITIAL PRODUCT ONLY)
EVIDENCE OF OXIDATIVE CHANGE
EVIDENCE OF BROWNING
CALCULATED CALORIC VALUE (INITIAL PRODUCT ONLY)
PER (INITIAL PRODUCT ONLY)

PROGRESS REPORTS WERE SUBMITTED AT THE END OF EACH FOUR-MONTH PERIOD. A FINAL REPORT WILL BE SUBMITTED 30 DAYS AFTER APPROVAL OF THE INITIAL DRAFT BY THE GOVERNMENT. PRIOR TO THE SUBMISSION OF THE FINAL REPORT, 0.5 KG OF DRY PRODUCT REPRESENTING THAT WHICH PERFORMED MOST SATISFACTORILY IN THE STORAGE PROGRAM WAS TO BE SUBMITTED TO THE PROJECT OFFICER.

A DISCUSSION OF PROCESSING, PACKAGING AND STORAGE, FLAVOR EVALUATIONS, RECOMMENDED FORMULATION AND PROCESSING PROCEDURE, AND CONCLUSIONS AND RECOMMENDATIONS IS INCLUDED IN THIS REPORT.

PROCESSING

THE PROCESSING STUDY WAS COMPOSED OF SIX SERIES OF PILOT PLANT TRIALS. SERIES 1 THROUGH 3 WERE DESIGNED TO DEVELOP THE FORMULA, SCREEN OIL SOURCES, ANTIOXIDANTS, AND EMULSIFIERS, AND FINALIZE THE PROCESSING CONDITIONS. SERIES 4 THROUGH 6 WERE DESIGNED TO USE THE DEVELOPED FORMULATION AND PROCESS IN CONJUNCTION WITH CONTROLLED STORAGE TO (1) DIFFERENTIATE BETWEEN FAT SOURCES, (2) DEMONSTRATE THE EFFECT OF EMULSIFICATION, (3) DETERMINE THE NEED FOR ANTIOXIDANTS, (4) EVALUATE STEAM AND WATER INSTANTIZING, AND (5) EVALUATE VARIOUS WETTING AGENTS.

THE PURPOSE OF SERIES 1 WAS TO DEVELOP THE BASIC PROCESSING PROCEDURE INCLUDING CONCENTRATION, HOMOGENIZATION, SPRAY DRYING, INSTANTIZING, AND SCREEN ALTERNATE VEGETABLE OIL SOURCES. THE FORMULA USED FOR THESE TESTS CONTAINED A SOLIDS NOT FAT TO FAT RATIO OF 8/2. THIS WAS DESIGNED TO YIELD A RECONSTITUTED PRODUCT AT 10% TOTAL SOLIDS AND 2.0% FAT. THE VEGETABLE OILS SELECTED WERE CONSIDERED REPRESENTATIVE OF COMMON OILS USED FOR THIS APPLICATION. THESE OILS INCLUDED HYDROL 92[1] (A 92° MELTING POINT COCONUT OIL), KAOMEL[1] (A 100° MELTING POINT DOMESTIC OIL), AND PARAMOUNT X[1] (A 114° MELTING POINT HARD BUTTER).

THROUGH EXPERIENCE WITH OTHER PRODUCTS OF THIS NATURE THE FOLLOWING PROCESSING PROCEDURE WAS EMPLOYED TO PRODUCE THE INITIAL INSTANTIZED POWDER. RAW SKIM MILK TESTING APPROXIMATELY 8.6% TOTAL SOLIDS[2] WAS PREHEATED BY PLATE HEAT EXCHANGER TO 180°F AND HELD FOR 15 TO 20 SECONDS PRIOR TO ENTERING THE EVAPORATOR. THE HARRIS FALLING FILM EVAPORATOR WAS OPERATED AT 27" VACUUM AND 110°F TO 120°F TEMPERATURE. THE RESULTANT CONDENSED SKIM MILK TESTED 36% TOTAL SOLIDS WITH 0.3% FAT[3].

THE CONDENSED SKIM WAS DIVIDED INTO THREE PARTS TO ACCOMMODATE THE VEGETABLE OIL VARIABLES. EACH VEGETABLE OIL WAS ADDED TO 140°F CONDENSED SKIM. THIS MIXTURE WAS RAISED TO 160°F AND HELD FOR 10 MINUTES PRIOR TO HOMOGENIZATION. FOUR HOMOGENIZATION CONDITIONS WERE CONDUCTED ON EACH VEGETABLE OIL AND THE RESULTS WERE MEASURED MICROSCOPICALLY[4]. THESE VARIABLES WERE RUN ON A 2-STAGE CP HOMOGENIZER OPERATING WITH FIRST AND SECOND STAGE PRESSURES OF 1500 + 500, 2000 + 500, 2500 + 500, AND 3000 + 500. THESE WERE THEN PLATE COOLED TO 40°F PRIOR TO SPRAY DRYING. THE TEST RESULTS INDICATED THAT A FIRST STAGE PRESSURE OF 3000 PSIG AND A SECOND STAGE PSIG OF 500 GAVE THE BEST HOMOGENIZATION CONDITIONS. THIS LEVEL OF HOMOGENIZATION WAS EMPLOYED IN ALL FUTURE VARIABLES.

THE THREE SKIM CONDENSED VEGETABLE OIL MIXTURES WERE THEN SPRAY DRIED IN A 6 FT. X 40 FT. COCURRENT TOWER DRYER EMPLOYING A CYCLONE RECOVERY SYSTEM. THE FEED STOCK WAS PREHEATED TO 150°F PRIOR TO THE DRYER AND DELAVAN SC-35[5] NOZZLE

[1] GLIDDEN-DURKEE COMPANY, CHICAGO, ILLINOIS.

[2] METHOD OF ANALYSIS OF MILK AND ITS PRODUCTS, MILK INDUSTRY FOUNDATION, WASHINGTON, D.C. 3RD EDITION, 1959. PAGE 287

[3] IBID. PAGE 273

[4] IBID. PAGE 444

[5] DELAVAN MANUFACTURING COMPANY, WEST DES MOINES, IOWA 50265

OPERATING AT 2500 PSIG WAS USED TO ACCOMPLISH ATOMIZATION IN THE DRYER FOR ALL VARIABLES. THE DRYER WAS OPERATED WITH AN AVERAGE INLET TEMPERATURE OF 355°F AND AN EXHAUST AVERAGE OF 185°F. THE RESULTANT POWDER WAS DRIED TO APPROXIMATELY 2.0% I.R. MOISTURE CONTENT[6]. THE DRIED POWDER WAS COOLED IN A COCURRENT AIR STREAM TO AN AVERAGE TEMPERATURE OF 100°F PRIOR TO INSTANTIZING.

THE INSTANTIZING PROCESS DEVELOPMENT WAS DIVIDED INTO WATER AND STEAM AGGLOMERATION FOR EACH VARIABLE. PRIOR TO AGGLOMERATION ALL DRY POWDERS WERE PRECONDITIONED BY BLENDING WITH 1.0% SEED LACTOSE[7]. IN THE WATER METHOD THE PRECONDITIONED DRY POWDER WAS METERED INTO AN AIR STREAM WHICH CONVEYED THE MATERIAL BY CONDUIT TO THE HYDRATION CHAMBER WHERE IT WAS MIXED WITH APPROXIMATELY 13.0% WATER CONTAINING 0.5% CENTROLENE-S LECITHIN[8] AS A WETTING AND/OR HYDRATION AID. THE WATER WAS ADDED TO THE DRY POWDER AT THE OUTLET OF THE POWDER CONVEYING CONDUIT AT THE TOP OF THE HYDRATION CHAMBER BY MEANS OF A HIGH PRESSURE NOZZLE ARRANGEMENT. THE WET AGGLOMERATE CONTAINING THE LACTOSE SEED CRYSTALS THEN PASSED ONTO A HOLDING BELT WITH ONE MINUTE DURATION FOR LACTOSE CONVERSION FROM THE HYDROUS TO ANHYDROUS FORM. THIS STEP IS NEEDED TO ACHIEVE AGGLOMERATES WITH DESIRABLE TEXTURE, DENSITY, ANTICAKING, DISPERSION, AND FLAVOR CHARACTERISTICS. THE AGGLOMERATED MAT WAS THEN CHOPPED UP BY MEANS OF WIRE BREAK-UP WHEEL AND PASSED ONTO A TRAY DRYER FOR REDRYING. THE DRYER WAS OPERATED AT 275°F/240°F FOR THE FIRST AND SECOND SECTIONS RESPECTIVELY AND DRIED THE MATERIAL TO 3.5 TO 3.8% MOISTURE CONTENT. THE DRIED PRODUCTS WERE THEN TRAY COOLED TO APPROXIMATELY 50°F PRIOR TO EVALUATION.

THE STEAM METHOD FOR AGGLOMERATION PROCEDURE EMPLOYED THE SAME BASIC EQUIPMENT AS THAT USED FOR THE WATER INSTANTIZING METHOD; THE DIFFERENCE WAS IN THE METHOD OF INCORPORATING THE WATER AND LECITHIN INTO THE AGGLOMERATE OUT OF THE HYDRATION CHAMBER. IN THE STEAM CONFIGURATION THE PRECONDITIONED POWDER WAS METERED INTO AN AIR CONVEYING CONDUIT AND THE POWDER WAS DELIVERED TO THE HYDRATION CHAMBER BY MEANS OF A CYCLONE SEPARATOR. AT THIS POINT THE POWDER WAS MIXED WITH LOW PRESSURE SUPERHEATED STEAM AND WATER CONTAINING 2.0% LECITHIN. THE WATER-LECITHIN MIXTURE WAS INJECTED INTO THE STEAM BY MEANS OF A HIGH PRESSURE PUMP AND NOZZLE ARRANGEMENT SIMILAR TO THAT USED IN THE WATER-ONLY HYDRATION METHOD. IN THIS PROCEDURE APPROXIMATELY 8.0% MOISTURE WAS ADDED YIELDING A PRODUCT OUT OF THE HYDRATION CHAMBER CONTAINING 10.5% MOISTURE.

AS IN THE WATER HYDRATION METHOD, THE HOLDING TIME ON THE BELT WAS APPROXIMATELY 1.0 MINUTE FOR LACTOSE CONVERSION AND PRODUCT WAS REDRIED AND COOLED USING SIMILAR CONDITIONS.

FROM THE RESULTS OF THE FIRST PROCESSING STUDY, IT WAS CONCLUDED THAT:

1. THE BASIC PROCESS USED WOULD BE EMPLOYED FOR ALL FUTURE TESTS UNLESS OTHERWISE STATED.

[6]METHODS OF ANALYSIS OF MILK AND ITS PRODUCTS, MILK INDUSTRY FOUNDATION WASHINGTON, D.C. 3RD EDITION, 1959. PAGE 296

[7]EDIBLE LACTOSE, GRIND A (306). FOREMOST FOODS, SAN FRANCISCO, CALIF.

[8]CENTRAL SOYA COMPANY, CHICAGO, ILLINOIS 60639

2. Steam and water instantizing both seemed feasible at this time. The water method had slightly slower dispersion with better surface appearance. The steam method had slightly better dispersion, but the surface after 5 minutes had an unnatural foam.

3. The lecithination level in the finished dry product at about 0.05% seemed adequate with respect to dispersion and flavor characteristics.

4. The Hydrol 92 product had the best dispersion - about 30 seconds. The Kaomel had 45 seconds and the Paramdunt X required 60 seconds.

Based on the product evaluation of this group of tests, the next tests included the following changes.

1. Produce dry basic powder at 3.5% moisture levels to improve solubility.

2. Use 2.0% seed lactose in the preblend prior to instantizing to achieve better lactose conversion. In conjunction with this, add 0.125% silicon didxide[9] to the blender as an aid to mixing and metering in the instantizing process.

3. Adjust the percent fat and solids-not-fat of the dry powder to a ratio that more closely matches that of 2.0% fat milk in the USDA Handbook #8. This is equal to 2.0% fat and 11.0% solids-not-fat, which in turn yields dry powder containing 15.4% fat.

Series 2 included the recommendations listed above. In conjunction with these, the addition of an emulsifier in the mix preparation was tested; also the addition of various wetting agents was studied in the water and steam agglomeration processes. Hydrol 92 and Hydrol 92 emulsified with Atmos 150[10], a mono- and diglyceride, were used as the fat sources for this series. Based on the supplier's recommendations, Atmos 150 was used at the rate of 7.14% on a fat basis.

In these trials the condensed skim milk was prepared as in series 1 and both products were standardized to yield dry milk powder containing 15.4% fat. The skim condensed was heated by plate heater to 180°F and added to a pasteurizing vat. The Hydrol 92 was added directly to the heated condensed skim milk. The Hydrol 92-Atmos 150 mix was preheated to 150°F prior to addition. Both fats were mixed thoroughly for 10 minutes and homogenized at 2500 + 500 psig as the homogenizer would not function at the desired 3000 + 500 psig. Homogenization efficiencies were rated fair and good respectively.

Each product was dried as before with reduced inlet temperatures ranging from 305°F to 330°F. The resultant dry powder had an average moisture content of 3.0% with densities ranging from .40 to .42 grams/cc.

[9]Syloid 244, W. R. Grace, Inc., Baltimore, Maryland.

[10]ICI America, Inc., Wilmington, Delaware.

THE powders WERE INSTANTIZED WITH WATER AND STEAM AS THE INSTANTIZING MEDIA WITH LECITHIN, DIOCTYL SODIUM SULFOSUCCINATE (DSS)[11], AND COMBINATIONS OF LECITHIN AND DSS AS THE SURFACE COATING WETTING AGENT IN EACH PROCESS. IN THE WATER ONLY PROCEDURE THE CALCULATED LECITHIN AND DSS LEVELS IN THE RECONSTITUTED MILK WERE 0.012% AND 0.0026% RESPECTIVELY. IN THE STEAM PROCEDURE THESE WERE 0.007% LECITHIN AND 0.0024% DSS.

SERIES 2 WAS CODED AS FOLLOWS:

CODE	FAT SOURCE	EMULSIFIER	ANTIOXIDANT	INSTANTIZING METHOD	WETTING AGENT
2-4	HYDROL 92	ATMOS 150	--	WATER	DSS
2-5	HYDROL 92	ATMOS 150	--	WATER	DSS, CENTROLENE-S
2-6	HYDROL 92	ATMOS 150	--	WATER	CENTROLENE-S
2-7	HYDROL 92	--	--	STEAM	DSS
2-8	HYDROL 92	--	--	STEAM	CENTROLENE-S
2-9	HYDROL 92	--	--	STEAM	DSS, CENTROLENE-S
2-10	HYDROL 92	ATMOS 150	--	STEAM	DSS, CENTROLENE-S

THE PERFORMANCE OF THE INSTANTIZED DRY PRODUCTS FOR THESE TESTS WAS EVALUATED ACCORDING TO THE FOLLOWING PROCEDURE which WAS DESIGNED TO YIELD FORTIFIED 2.0% FAT MILK AS STATED IN THE USDA HANDBOOK #8 AND WILL BE USED THROUGHOUT THE ENTIRE STUDY AS A MEANS OF STANDARDIZING TEST DATA.

1. ADD 32.0 GM OF POWDER TO 400 ML BEAKER.
2. TO THIS ADD 210 ML OF 60°F WATER AND MIX WITH A SPOON UNTIL VISUALLY DISSOLVED AND RECORD RECONSTITUTION TIME IN SECONDS.
3. RESTIR AT THE END OF 2.0 MINUTES - ABOUT 10 SWIRLS OF THE SPOON.
4. WAIT 2-3 MINUTES AND EVALUATE SURFACE AND SCORE FLAVOR HEDONICALLY ACCORDING TO THE FOLLOWING 9-POINT SCALE.

1. OBJECTIONABLE
2. UNDESIRABLE
3. MODERATELY UNDESIRABLE
4. SLIGHTLY UNDESIRABLE
5. NO STRONG LIKE OR DISLIKE
6. SLIGHTLY DESIRABLE
7. DESIRABLE
8. VERY DESIRABLE
9. EXCELLENT

[11]COMFLEMIX, AMERICAN CYANAMID COMPANY, PEARL RIVER, NEW YORK.

RESULTS OF THE SERIES 2 TESTS WERE AS FOLLOWS:

WATER INSTANTIZED

CODE	2-4	2-5	2-6
RECON. TIME (SEC.)	45	30	30
FOAM X 1/32 IN. thick	4	2	4
FLAVOR	6.0	6.0	6.0

STEAM INSTANTIZED

CODE	2-7	2-8	2-9	2-10
RECON. TIME (SEC.)	45	45	45	20
FOAM X 1/32 IN. thick	2	2	2	2
FLAVOR	6.5	6.0	6.5	6.5

TO FAMILIARIZE THE EXPERT TASTE PANEL WITH THE TEST PRODUCT OF THIS STUDY, THE VARIABLES FROM THIS SERIES WERE RECONSTITUTED TO A FAT LEVEL OF 2.0% AND COMPARED TO MARKET 2.0% MILK. THIS STUDY INDICATED THAT ALL SAMPLES WERE RELATIVELY CLOSE TO THE CONTROL WITH RESPECT TO FLAVOR. THOSE INSTANTIZED WITH LECITHIN AND COMBINATIONS OF LECITHIN AND DSS WERE PREFERRED, WITH THE DSS SAMPLE LACKING FLAVOR CHARACTER. THE PANEL TESTS INDICATED THAT ONLY SLIGHT REFINEMENTS WERE NEEDED TO MATCH THE FLAVOR OF THE FRESH PRODUCT AND MOST AGREED THAT THIS WOULD PROBABLY BE IN THE AREA OF THE SURFACE COATING AGENTS.

AFTER EVALUATING THE DATA FROM THIS SERIES, THE FOLLOWING CONCLUSIONS AND GUIDELINES WERE DERIVED.

1. INCREASED LACTOSE AT 2.0% SEEMED TO HELP LACTOSE CONVERSION AND WILL BE USED IN SUCCEEDING TESTS.

2. SILICON DIOXIDE AT 0.125% AIDS BLENDING AND PRODUCT DISTRIBUTION IN THE INSTANTIZER. THIS WILL BE EMPLOYED IN FUTURE RUNS.

3. LECITHINATED PRODUCT SEEMS TO HAVE THE BEST RECONSTITUTED SURFACE WHEN COMPARED TO THAT MADE WITH DSS.

4. THE DSS SAMPLES HAD A CLEAN FLAVOR WITH IMPROVED MOUTHFEEL. IN THE NEXT TESTS AN INCREASED LEVEL WILL BE ATTEMPTED AS A MEANS OF IMPROVING DISPERSION AND FLAVOR CHARACTERISTICS.

5. LECITHIN LEVEL MAY BE TOO HIGH; IN THE NEXT TESTS LECITHINS WITH LOWER FLAVOR IDENTITIES WILL BE STUDIED.

6. COMBINATIONS OF DSS AND LECITHIN SEEM TO SHOW THE MOST POTENTIAL AS A MEANS OF ACHIEVING DESIRED SOLUBILITY WITH MINIMUM FLAVOR DEFECTS.

7. WATER APPEARS TO BE THE BEST METHOD OF INSTANTIZING AS THE SURFACE OF THE RECONSTITUTED PRODUCTS DEMONSTRATE LESS FOAMING TENDENCY. BOTH SYSTEMS WILL BE EVALUATED FURTHER.

8. PRODUCT WITH THE EMULSIFIED FAT SYSTEM APPEARED TO HAVE IMPROVED HOMOGENIZATION AND SLIGHTLY BETTER DISPERSION. THERE WAS ALSO A BENEFIT TO FLAVOR CHARACTERISTICS AND MOUTHFEEL. THIS EMULSIFIER LEVEL (7.14% ON A FAT BASIS) WILL BE USED FOR ALL FURTHER TESTS.

9. EFFORT SHOULD BE PLACED ON A MEANS OF ELIMINATING THE FOAM THAT APPEARS ON THE SURFACE OF THE RECONSTITUTED PRODUCT.

SERIES 3 WAS DESIGNED TO EVALUATE DIFFERENT LECITHIN SOURCES AND DSS LEVELS IN THE INSTANTIZER, TEST ANTIOXIDANTS IN THE VEGETABLE OIL SYSTEM, SCREEN VARIOUS FLAVOR ENHANCERS, AND REDUCE FOAMING IN THE FINISHED PRODUCT.

ALTERNATE LOW FLAVOR LECITHINS WERE OBTAINED AND TESTS ON THE BENCH DETERMINED THEIR USE LEVELS. THESE TESTS INDICATED THAT CENTROLENE-S, THE LECITHIN CURRENTLY BEING USED, COULD BE TASTED AT 0.02% OF THE FINISHED MILK PRODUCT AND THE NEW LECITHIN SOURCES, CENTROMIX-C[12] AND CENTROPHIL 64-CX[12], COULD BE TASTED AT LEVELS OF 0.05% AND 0.10% RESPECTIVELY. DSS WAS ALSO TESTED IN MILK AT THIS TIME ON THE BENCH AND IT WAS DETERMINED THAT LEVELS OF 0.005% IMPARTED A BITTER NOTE. IN THESE TESTS IT WAS PLANNED TO ADD THE LECITHIN SOURCES AND DSS AT LEVELS SLIGHTLY BELOW THRESHOLD.

TWO ANTIOXIDANTS, TENOX A[13] AND TENOX 4[13], WERE INCORPORATED INTO THE OIL OF TWO VARIABLES AT THE SUPPLIER'S RECOMMENDED LEVEL OF 0.05% OF THE TOTAL OIL PRESENT.

IT WAS THE OBJECT OF ADDITIONAL BENCH STUDIES TO INVESTIGATE THE ADDITION OF VARIOUS FLAVOR ADJUNCTS AS A MEANS OF UPGRADING THE SHELF LIFE AND THE FLAVOR OF THE FINISHED MILK DRINK. IN THIS STUDY SALT, SUGAR, AND VANILLIN LEVELS WERE SCREENED AND IT WAS DETERMINED THAT SALT AT 0.01% IN COMBINATION WITH SUGAR AT 0.2% AND VANILLIN AT 0.00025% OF THE LIQUID MILK GAVE THE APPEARANCE OF A RICHER END PRODUCT. IN CONJUNCTION WITH THESE STUDIES, ALTERNATE MILK FLAVOR SYSTEMS FROM VARIOUS SUPPLIERS WERE SCREENED. THESE DATA INDICATED THAT THE MOST ACCEPTABLE FLAVOR WAS IMITATION MILK FLAVOR[14] AT 0.0075% OF THE LIQUID PRODUCT. THESE LEVELS FOR SALT, SUGAR, VANILLIN, AND ARTIFICIAL FLAVOR WERE INCORPORATED INTO THIS SERIES FOR FURTHER TESTING.

IN AN EFFORT TO REDUCE OR MINIMIZE THE FOAM OF THE RECONSTITUTED MILK, IT WAS DECIDED TO STUDY THE EFFECT OF DRYER TEMPERATURE, SPRAY PRESSURE, AND PREHEAT TEMPERATURE ON THE BULK DENSITY OF THE BASIC POWDER. THE HYPOTHESIS PROPOSED WAS THAT A MORE DENSE BASIC POWDER SHOULD UPON INSTANTIZING YIELD A PRODUCT WITH LESS OCCLUDED AIR AND MORE CAPILLARY ACTION.

THE SKIM MILK WAS CONDENSED AND STANDARDIZED AS IN SERIES 2. TWO OIL SYSTEM VARIABLES WERE KEYED OFF OF HYDROL 92 AND ATMOS 150; ONE CONTAINED TENOX A, THE OTHER TENOX 4. BOTH WERE PREHEATED TO 150°F PRIOR TO MIXING WITH THE CONDENSED SKIM. IN BOTH CASES THE HOMOGENIZER WAS OPERATED AT 3000 + 500 AND YIELDED "VERY GOOD" HOMOGENIZATION EFFICIENCIES PRIOR TO COOLING AND SPRAY DRYING.

[12]CENTRAL SOYA COMPANY, CHICAGO, ILLINOIS
[13]EASTMAN CHEMICAL PRODUCTS, KINGSPORT, TENNESSEE
[14]NO. 115-20-14/AP,50.51 FIRMENICH INC., NEW YORK, NEW YORK

AS A MEANS OF INCREASING BASIC POWDER BULK DENSITY THE DRYER WAS OPERATED AS IN SERIES 2 WITH A 150°F EXHAUST TEMPERATURE; THE AVERAGE INLET TEMPERATURE RANGED FROM 300° TO 275°F WITH RESPECTIVE PRODUCT FEED PRESSURES OF 2500 AND 1100 PSIG.

AT EACH FEED PRESSURE THE PRODUCT PREHEAT TEMPERATURE WAS VARIED FROM 70°F TO 150°F. THE POWDERS PRODUCED UNDER THESE CONDITIONS HAD AN AVERAGE MOISTURE CONTENT OF 4.0% AFTER COOLING. BASED ON THESE TESTS IT WAS DETERMINED THAT REDUCED FEED PRESSURE AND TEMPERATURE YIELD A 10.0% INCREASE IN BASIC POWDER DENSITY.

THE INSTANTIZING OF THESE POWDERS FOLLOWED THE WATER PROCEDURE OF SERIES 2 WITH 2.0% LACTOSE AND 0.125% SILICON DIOXIDE ADDED. THE VARIOUS WETTING AGENTS WERE ADDED AT THE LEVELS PREVIOUSLY DISCUSSED. IN THE LECITHIN VARIABLES DSS WAS COMBINED WITH LECITHINS TO AID IN INSTANTIZING WATER DISPERSION. THE FLAVOR SYSTEMS WERE ADDED TO THE BLENDER PRIOR TO INSTANTIZING.

THE FOLLOWING CODES WERE ASSIGNED TO THESE PRODUCTS.

Code	Fat Source	Emul-sifier	Anti-oxidant	Instan-tizing Method	Wetting Agent	Flavor
3-11	Hydrol 92	Atmos 150	Tenox 4	Water	DSS, Centromix-C	
3-12	Hydrol 92	Atmos 150	Tenox 4	Water	DSS, Centrophil 64-CX	
3-13	Hydrol 92	Atmos 150	Tenox 4	Water	DSS	
3-14	Hydrol 92	Atmos 150	Tenox A	Water	DSS	
3-15	Hydrol 92	Atmos 150	Tenox A	Water	DSS, Centrophil 64-CX	
3-16	Hydrol 92	Atmos 150	Tenox A	Water	DSS, Centromix-C	Sugar, salt, vanillin
3-17	Hydrol 92	Atmos 150	Tenox A	Water	DSS, Centromix-C	Sugar, salt, milk flavor

THESE VARIABLES WERE EVALUATED ACCORDING TO THE PROCEDURE ESTABLISHED IN SERIES 2 AND THE RESULTS WERE AS FOLLOWS:

Code	3-11	3-12	3-13	3-14	3-15	3-16	3-17
Recon. Time (Sec.)	20	15	15	30	15	15	15
Foam X 1/32 in. thick	4	1	2	4	4	4	4
Flavor	5.0	5.5	5.0	6.0	5.0	5.5	6.0

THE FOLLOWING CONCLUSIONS AND OBJECTIVES FOR FUTURE TESTS WERE DERIVED FROM THIS SERIES.

1. THE VARIATION IN BASIC SPRAY DRYING CONDITIONS HAS NOT REDUCED THE AMOUNT OF SURFACE FOAM AFTER RECONSTITUTION. IN THE NEXT TESTS VACUUM TREATMENT OF THE LIQUID MIX PRIOR TO HOMOGENIZATION AND SPRAY DRYING WILL BE EMPLOYED AS A MEANS OF MINIMIZING THE FOAM.

2. THE INCREASED DSS LEVEL, .004% OF THE FINISHED MILK DRINK, IS TOO HIGH. WHEN TASTED, A SLIGHTLY BITTER FLAVOR WAS DETECTED. FUTURE RUNS WILL INCLUDE 0.003%.

3. CENTROPHIL 64-CX LECITHIN EXHIBITED BETTER DISPERSION AND FLAVOR CHARACTERISTICS WHEN COMPARED TO THE CENTROMIX-C LECITHIN. FUTURE TESTS WILL INCLUDE A COMPARISON OF CENTROPHIL 64-CX AND CENTROLENE-S.

4. FLAVOR STUDIES DID NOT INDICATE ANY DIFFERENCE BETWEEN THE TWO ANTIOXIDANTS STUDIED. BOTH WILL BE EVALUATED FURTHER TO DETERMINE THE MATERIAL OF PREFERENCE.

5. THE TWO products CONTAINING FLAVOR ADDITIVES WERE TASTED BY A LIMITED TASTE PANEL. THESE RESULTS INDICATED THAT THE PRODUCTS WERE COMPARABLE TO THE BENCH SAMPLES. THEY WERE BOTH CONSIDERED A SLIGHT IMPROVEMENT WHEN COMPARED TO THE CONTROL WITH RICHER FLAVOR CHARACTERISTICS. VARIATION OF THIS FLAVOR SYSTEM WILL BE INCORPORATED INTO FUTURE VARIABLES AND PLACED ON STORAGE. BASED ON WORK WITH NONFAT DRY MILK, FLAVOR ADJUNCTS CAN PROLONG THE SHELF LIFE OF DRY MILK PRODUCTS.

SERIES 4 WAS DESIGNED TO EVALUATE VACUUM TREATMENT OF THE CONDENSED SKIM PRIOR TO HOMOGENIZATION AS A MEANS OF MINIMIZING THE SURFACE FOAM OF THE RECONSTITUTED PRODUCTS. IN CONJUNCTION WITH THIS THE HYDROL 92, KADMEL, AND PARAMOUNT X WERE RE-EVALUATED WITH RESPECT TO THE CHANGES IN THE WATER INSTANTIZED PROCEDURE. REPRESENTATIVE SAMPLES OF EACH VARIABLE WERE PACKAGED ACCORDING TO THE GUIDELINES SET FORTH IN THE ORIGINAL PROPOSAL AND PLACED ON CONTROLLED STORAGE AT 18°, 28°, AND 38°C TO STUDY PRODUCT STABILITY.

THE SKIM MILK WAS CONDENSED AS BEFORE AND THE FAT WAS ADDED AT A LEVEL TO YIELD 2.0% FAT WHEN RECONSTITUTED. FOR EACH FAT VARIABLE THE CONDENSED SKIM AND VEGETABLE OIL WERE BOTH PREHEATED TO 150°F PRIOR TO MIXING. THESE MIXTURES WERE THEN HEATED TO 165-177°F AND FLASHED INTO A VACUUM CHAMBER OPERATING AT 12" TO 14" VACUUM AND 145° TO 150°F. AFTER THE VACUUM TREATMENT, ALL MIXES WERE HOMOGENIZED AT 3000 + 500 PSIG AND COOLED PRIOR TO SPRAY DRYING. THE HOMOGENIZATION EFFICIENCIES WERE GOOD FOR HYDROL 92, FAIR FOR KADMEL, AND POOR FOR PARAMOUNT X. THIS VARIATION WAS PROBABLY CAUSED BY INADEQUATE PRODUCT SUPPLY FROM THE VACUUM CHAMBER TO THE HOMOGENIZER AND WATER DILUTION.

THESE MIXES WERE SPRAY DRIED WITHOUT PREHEAT AT 2500 PSIG USING A SC-35 NOZZLE. THE DRYER WAS OPERATED WITH 150°F EXHAUST TEMPERATURE AND THE INLET VARIED 320° TO 340°F. THE RESULTANT DRY BASIC POWDERS HAD AN AVERAGE MOISTURE CONTENT OF 4.2% AND EXHIBITED A 20% INCREASE IN BULK DENSITY OVER PREVIOUSLY DRIED PRODUCTS.

WATER INSTANTIZING WITH VARIOUS WETTING AGENTS AT REDUCED LEVELS WAS USED IN THESE TESTS. THE DSS WAS AT A LEVEL EQUAL TO 0.003% OF THE RECONSTITUTED FINISHED PRODUCT. THE CENTROLENE S AND CENTROPHIL 64-CX WERE ADDED TO YIELD A FINISHED MILK DRINK CONTAINING 0.009% AND 0.02% RESPECTIVELY. THE MOISTURE CONTENT OF THE INSTANTIZED PRODUCT RANGED FROM 3.2 TO 3.8% AND THE AVERAGE BULK DENSITY WAS .23 GM/CC.

THE FOLLOWING CODES WERE ASSIGNED TO SERIES 4.

CODE	FAT SOURCE	EMULSIFIER	ANTIOXIDANT	INSTANTIZING METHOD	WETTING AGENT
4-18	HYDROL 92	--	--	WATER	CENTROLENE-S
4-19	KAOMEL	--	--	WATER	CENTROLENE-S
4-20	PARAMOUNT X	--	--	WATER	CENTROLENE-S
4-21	PARAMOUNT X	--	--	WATER	DSS, CENTROPHIL 64-CX
4-22	KAOMEL	--	--	WATER	DSS, CENTROPHIL 64-CX
4-23	HYDROL 92	--	--	WATER	DSS, CENTROPHIL 64-CX
4-24	HYDROL 92	--	--	WATER	DSS

THESE PRODUCTS WERE EVALUATED FOLLOWING THE PROCEDURE DESCRIBED PREVIOUSLY.

CODE	4-18	4-19	4-20	4-21	4-22	4-23	4-24
RECON. TIME (SEC.)	60	60	30	30	60	90	45
FOAM x 1/32 IN. THICK	2	2	2	2	2	2	2
FLAVOR	6.0	6.0	6.0	5.5*	6.0*	6.0*	6.0

*SLIGHT LECITHIN FLAVOR DETECTED.

FROM THESE DATA IT WAS CONCLUDED THAT:

1. THE VACUUM TREATMENT SEEMED TO HELP THE FOAMING CHARACTERISTIC OF THE RECONSTITUTED PRODUCT. THE FOAM WAS NOT ELIMINATED BUT WAS CUT APPROXIMATELY IN HALF. ALL FUTURE VARIABLES WILL INCLUDE THIS STEP IN PROCESSING.

2. AFTER INSTANTIZING, THE CENTROPHIL 64-CX GROUP EXHIBITED COMPARABLE WETTING CHARACTERISTICS WHEN COMPARED TO THE CENTROLENE-S GROUP WITH THE CENTROLENE-S GROUP HAVING SUPERIOR FLAVOR CHARACTERISTICS. FOR THESE REASONS IT WAS DECIDED TO USE THE CENTROLENE-S LECITHIN IN ALL FUTURE LECITHINIZATION VARIABLES AT 0.009% OF THE RECONSTITUTED PRODUCT.

3. DSS AT 0.003% OF THE RECONSTITUTED PRODUCT DEMONSTRATED FAIR DISPERSION CHARACTERISTICS WITH THE ABSENCE OF A BITTER AFTERTASTE. THIS LEVEL WILL BE USED IN THE REMAINING VARIABLES OF THIS STUDY.

4. THE VARIOUS OILS DID NOT EXHIBIT ANY DEFINITE TRENDS WITH RESPECT TO DISPERSION AND FLAVOR. IN ALL CASES THESE CHARACTERISTICS WERE CONSIDERED ACCEPTABLE. THEREFORE, ALL SOURCES WILL BE INCLUDED IN THE CONTROLLED SHELF LIFE STUDY.

SERIES 5 WAS DESIGNED TO EVALUATE AN OIL SYSTEM OF HYDROL 92 AND ATMOS 150 WITH AND WITHOUT ANTIOXIDANTS. ATMOS 150 ADDED AT 7.14% OF THE OIL WAS USED IN ALL SUBSEQUENT VARIABLES AS PRECEDING STUDIES INDICATED IMPROVED HOMOGENIZATION AND DRY INSTANT POWDER RECONSTITUTION WITH THE ADDITION OF THIS SURFACTANT. THE OTHER TWO CONTAINED TENOX A AND TENOX 4 AT 0.05% OF THE FAT. EACH OF THE BASIC POWDER VARIABLES WAS INSTANTIZED WITH WATER CONTAINING DSS ONLY AND A COMBINATION OF DSS AND LECITHIN. IN BOTH SERIES THE DSS WAS ADDED AT A RATE TO YIELD A RECONSTITUTED PRODUCT CONTAINING 0.003% DSS. THE LECITHIN WAS ADDED TO ACHIEVE 0.009% OF THE RECONSTITUTED PRODUCT.

THE SKIM MILK WAS CONDENSED AS BEFORE AND THE OIL VARIABLES WERE STANDARDIZED TO YIELD 2.0% OIL IN THE RECONSTITUTED PRODUCT. THE VARIABLES WERE PROCESSED AND VACUUM TREATED ACCORDING TO THE PROCEDURE OUTLINED IN SERIES 4 WITH ALL OIL COMPONENTS BEING PREHEATED TO 150°F PRIOR TO ADDITION. A CONSTANT FEED RATE WAS PROVIDED TO THE HOMOGENIZER BY BREAKING THE VACUUM IN THE VACUUM CHAMBER AFTER ALL PRODUCT HAD PASSED INTO THE CHAMBER AND WATER DILUTION WAS RESOLVED BY NOT SWITCHING TO WATER BETWEEN VARIABLES. TO SEGREGATE THE LOTS EXCESS PRODUCT WAS RUN WITH MIXTURES BEING DISCARDED. THIS PROCEDURE YIELDED EXCELLENT HOMOGENIZATION FOR ALL VARIABLES. THESE WERE THEN COOLED TO 40°F AND SPRAY DRIED ACCORDING TO THE CONDITIONS IN THE PRECEDING TESTS. THE DRYER INLET TEMPERATURE RANGED FROM 330 TO 355°F WITH AN AVERAGE EXHAUST TEMPERATURE OF 145°F. THE BASIC POWDER HAD AN AVERAGE MOISTURE CONTENT OF 4.5% WITH A DENSITY OF 0.61 GM/CC

THE VARIABLES WERE WATER INSTANTIZED ACCORDING TO THE METHOD DESCRIBED IN SERIES 1 USING THE WETTING AGENTS AND LEVELS DISCUSSED ABOVE. THE INSTANTIZED POWDERS WERE DRIED TO MOISTURE CONTENTS RANGING FROM 3.4 TO 3.8% WITH AN AVERAGE BULK DENSITY OF 0.25 GM/CC.

THE FOLLOWING CODES WERE ASSIGNED TO SERIES 5.

CODE	FAT SOURCE	EMULSIFIER	ANTIOXIDANT	INSTANTIZING METHOD	WETTING AGENT
5-25	HYDROL 92	ATMOS 150	--	WATER	DSS
5-26	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS
5-27	HYDROL 92	ATMOS 150	TENOX 4	WATER	DSS
5-28	HYDROL 92	ATMOS 150	TENOX 4	WATER	DSS, CENTROLENE-S
5-29	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S
5-30	HYDROL 92	ATMOS 150	--	WATER	DSS, CENTROLENE-S

ALL VARIABLES WERE RECONSTITUTED AND EVALUATED ACCORDING TO THE PROCEDURE IN SERIES 2 WITH THE FOLLOWING RESULTS.

CODE	5-25	5-26	5-27	5-28	5-29	5-30
RECON. TIME (SEC.)	30	30	30	45	30	30
FOAM x 1/32 IN. thick	2	2	2	2	2	2
FLAVOR	6.0	6.0	6.0	6.0*	6.0*	6.0*

*VERY SLIGHT LECITHIN FLAVOR WAS NOTED.

THE FOLLOWING COMMENTS AND DIRECTIONS WERE INDICATED FROM THESE TESTS.

1. ALL SAMPLES HAD GOOD DISPERSION AND RECONSTITUTION CHARACTERISTICS.

2. THE LECITHIN LEVEL IS STILL SLIGHTLY HIGH AND A REDUCED LEVEL WAS INDICATED FOR THE NEXT TESTS.

3. THE PRODUCTS INSTANTIZED WITH DSS ALONE HAD SLIGHTLY SUPERIOR FLAVOR.

4. NO FLAVOR DIFFERENCE WAS DETECTED BETWEEN THE ANTIOXIDANTS USED. BASED ON THIS AND THE RECOMMENDATION OF THE SUPPLIER, TENOX A IS THE ANTIOXIDANT OF CHOICE AND WILL BE USED IN THE REMAINING TESTS.

SERIES 6 WAS DESIGNED TO RE-EVALUATE THE THREE VEGETABLE OIL SOURCES IN COMBINATION WITH OTHER PREVIOUSLY DETERMINED OPTIMUM CONDITIONS; THESE CONDITIONS INCLUDED EMULSIFIER TYPE AND LEVEL, ANTIOXIDANT TYPE AND LEVEL, AS WELL AS THE SOURCE AND LEVEL OF WETTING AGENTS. THE HYDROL 92 GROUP INCLUDED TWO FLAVOR SYSTEMS ESTABLISHED IN SERIES 3. THESE VARIABLES WERE PROCESSED ACCORDING TO THE METHOD ESTABLISHED IN SERIES 4 AND 5 AND WERE STANDARDIZED TO BE COMPARABLE TO 2.0% MARKET MILK.

THE ATMOS 150 AND TENOX A WERE ADDED AT 7.14% AND 0.05% OF EACH OIL SYSTEM RESPECTIVELY. THE BASIC DRYER WAS OPERATED WITHOUT PREHEATING THE FEED STOCK; THE INLET TEMPERATURE RANGED FROM 360 TO 370°F MAINTAINING AN AVERAGE EXHAUST TEMPERATURE AT 180°F. THE DRY POWDER HAD MOISTURE CONTENTS RANGING FROM 3.4 TO 3.8% AND AN AVERAGE BULK DENSITY OF 0.59 GM/CC. THESE VARIABLES WERE STEAM AND WATER INSTANTIZED ACCORDING TO THE ESTABLISHED PROCEDURE WITH 2.0% SEED LACTOSE AND 0.125% SILICON DIOXIDE PREBLENDED INTO ALL PRODUCTS PRIOR TO INSTANTIZING.

THE HYDROL 92 GROUP WAS SUB-DIVIDED TO PROVIDE THREE FLAVOR VARIABLES AS WELL AS THE CONTROL.

6-33	NO FLAVOR
6-40	ADDED 0.01% SUGAR, 0.2% SALT, 0.00025% VANILLIN, 1.3% SODIUM CASEINATE
6-41	ADDED 0.01% SUGAR, 0.2% SALT, 0.0075% IMITATION MILK FLAVOR, 1.3% SODIUM CASEINATE
6-42	ADDED 0.01% SUGAR, 0.2% SALT, 0.000125% VANILLIN, 0.00375% IMITATION MILK FLAVOR, 1.3% SODIUM CASEINATE

IN BOTH THE STEAM AND WATER INSTANTIZING PROCEDURES THE DSS WAS ADDED AT A LEVEL COMPARABLE TO 0.003% OF THE RECONSTITUTED PRODUCT AND THE LECITHIN WAS ADDED ACCORDINGLY AT 0.007%.

THE WET MOISTURES DURING AGGLOMERATION RANGED FROM 14.0 TO 16.0% AND ALL PRODUCTS WERE REDRIED TO AN AVERAGE MOISTURE CONTENT OF 3.5% WITH A DENSITY OF 0.25 GM/CC FOR THE WATER PROCEDURE AND 0.21 GM/CC FOR THE STEAM.

THE FOLLOWING CODES WERE ASSIGNED TO SERIES 6.

CODE	FAT SOURCE	EMULSIFIER	ANTIOXIDANT	INSTANTIZING METHOD	WETTING AGENT	FLAVOR
6-31	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS	
6-32	HYDROL 92	ATMOS 150	TENOX A	WATER	CENTROLENE-S	
6-33	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	
6-34	HYDROL 92	ATMOS 150	TENOX A	STEAM	CENTROLENE-S	
6-35	HYDROL 92	ATMOS 150	TENOX A	STEAM	DSS, CENTROLENE-S	
6-36	KAOMEL	ATMOS 150	TENOX A	WATER	CENTROLENE-S	
6-37	KAOMEL	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	
6-38	PARAMOUNT X	ATMOS 150	TENOX A	WATER	CENTROLENE-S	
6-39	PARAMOUNT X	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	
6-40	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	SUGAR, SALT, VANILLIN
6-41	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	SUGAR, SALT, MILK FLAVOR
6-42	HYDROL 92	ATMOS 150	TENOX A	WATER	DSS, CENTROLENE-S	SUGAR, SALT, VANILLIN, MILK FLAVOR

ALL VARIABLES WERE RECONSTITUTED AND EVALUATED ACCORDING TO THE ESTABLISHED PROCEDURE WITH THE FOLLOWING RESULTS.

CODE	6-31	6-32	6-33	6-34	6-35	6-36	6-37	6-38	6-39	6-40	6-41	6-42
RECON. TIME (SEC.)	20	20	20	15	15	40	20	30	30	20	15	15
FOAM x 1/32 IN. THK.	4	4	4	2	2	4	4	4	4	2	2	2
FLAVOR	6.0	6.	6.0	4.5	5.5	4.0	4.5	5.0	5.5	5.0	5.0	5.5

PACKAGING AND STORAGE

Representative quantities of all series 4, 5, and 6 variables were packaged at 1.0 atmosphere using the American Can oxygen scavenger pouch system and the Champion Inc. standard vacuum pouch. These were placed on controlled storage at 18°, 28°, and 38°C for product stability studies.

American Can pouch stock structure (Maraflex 7F) consisted of polyester, foil, surlyn, oxygen scavenger, and surlyn[15]. The Champion pouch structure was similar without the scavenger. Both materials were designed to have good structural protection with very low gas migration and light penetration. The American Can system was chosen for the major portion of the studies as it had the added benefit of the oxygen scavenger. This pouch measured 6 in. by 9.5 in. and was filled with 100 grams of dry powder. The pouch was then sealed on a Top-Vac machine with the following cycle.

1. Evacuate sealing chamber to 27 in. vacuum.
2. Back flush with a mixture of 92% nitrogen and 8% hydrogen to remove residual oxygen and activate oxygen scavenger.
3. Evacuate second time to 27 in. vacuum.
4. Seal electronically.
5. Release vacuum and remove sealed pouch.

The Champion pouches were used primarily as a control to determine the need of an oxygen scavenger. They measured 6.75 in. by 10.75 in. and contained 100 grams of powder and were sealed according to the same procedure without hydrogen in the back flush gas.

The stored product was used to monitor the physical and flavor characteristics of the finished product in compliance with the objectives of the project. These tests included:

Moisture
Fat (initial product only)
Protein (initial product only)
Ash (initial product only)
Fat extracted with petroleum ether
Iodine value of fat (initial product only)
Evidence of oxidation
Evidence of browning
Calculated caloric value (initial product only)
PER (initial product only)

In addition to the required tests and as determined by previous product evaluations, dry product caking, reconstitution qualities, flavor, and foaming trends were studied at monthly intervals.

Product samples from series 6 were used for all analytical and physical evaluations with series 4 and 5 used for additional data in the area of moisture content, browning, flavor, caking, reconstitution, and foaming. Table 1 shows product composition of all samples included in the storage and flavor studies.

[15]American Can Company bulletin: The Oxygen Scavanger Laminate

TABLE 1

SAMPLE CODE IDENTIFICATION

Code	Fat Source	Emul-sifier	Anti-oxidant	Instan-tizing Method	Wetting Agent	Flavor
4-18	Hyorol 92	--	--	Water	Centrolene-S	
4-19	Kaomel	--	--	Water	Centrolene-S	
4-20	Paramount X	--	--	Water	Centrolene-S	
4-21	Paramount X	--	--	Water	DSS, Centrophil 64-CX	
4-22	Kaomel	--	--	Water	DSS, Centrophil 64-CX	
4-23	Hyorol 92	--	--	Water	DSS, Centrophil 64-CX	
4-24	Hyorol 92	--	--	Water	DSS	
5-25	Hyorol 92	Atmos 150	--	Water	DSS	
5-26	Hyorol 92	Atmos 150	Tenox A	Water	DSS	
5-27	Hyorol 92	Atmos 150	Tenox 4	Water	DSS	
5-28	Hydrol 92	Atmos 150	Tenox 4	Water	DSS, Centrolene-S	
5-29	Hydrol 92	Atmos 150	Tenox A	Water	DSS, Centrolene-S	
5-30	Hyorol 92	Atmos 150	--	Water	DSS, Centrolene-S	
6-31	Hydrol 92	Atmos 150	Tenox A	Water	DSS	
6-32	Hyorol 92	Atmos 150	Tenox A	Water	Centrolene-S	
6-33	Hydrol 92	Atmos 150	Tenox A	Water	DSS, Centrolene-S	
6-34	Hyorol 92	Atmos 150	Tenox A	Steam	Centrolene-S	
6-35	Hyorol 92	Atmos 150	Tenox A	Steam	DSS, Centrolene-S	
6-36	Kaomel	Atmos 150	Tenox A	Water	Centrolene-S	
6-37	Kaomel	Atmos 150	Tenox A	Water	DSS, Centrolene-S	
6-38	Paramount X	Atmos 150	Tenox A	Water	Centrolene-S	
6-39	Paramount X	Atmos 150	Tenox A	Water	DSS, Centrolene-S	
6-40	Hyorol 92	Atmos 150	Tenox A	Water	DSS, Centrolene-S	Sugar, salt, vanillin
6-41	Hyorol 92	Atmos 150	Tenox A	Water	DSS, Centrolene-S	Sugar, salt, milk flavor
6-42	Hyorol 92	Atmos 150	Tenox A	Water	DSS, Centrolene-S	Sugar, salt, vanillin, milk flavor

THE MOISTURE CONTENT OF THE DRY PRODUCTS WAS DETERMINED BY TOLUENE DISTILLATION[16]. THE INITIAL AND FINAL MOISTURE CONTENTS OF BOTH POUCH SYSTEMS AT 18°, 28°, AND 38°C HAVE BEEN INCLUDED IN TABLE 2 BELOW.

TABLE 2

MOISTURE CONTENT INITIALLY AND AT THE END OF 9 MONTHS' CONTROLLED STORAGE

		9TH MONTH					
		AMERICAN CAN			CHAMPION		
CODE	INITIAL	18°	28°	38°	18°	28°	38°
4-19	4.0	4.4	4.1	4.4			
4-20	4.3	4.6	4.3	4.4			
4-21	3.8	3.8	3.8	4.4			
4-22	4.2	3.2	4.1	4.4			
4-23	4.3	4.0	4.0	4.4			
4-24	4.1	4.0	3.8	4.4			
5-25	3.6	3.6	3.6	3.7	3.4	3.7	3.3
5-26	4.0	3.9	3.9	3.6	3.5	3.8	3.6
5-27	3.1	3.2	3.2	3.4	2.8	3.2	3.2
5-28	3.2	3.6	3.2	3.4	3.6	3.4	3.0
5-29	3.6	3.6	3.0	3.3	3.2	3.6	3.4
5-30	3.4	3.8	4.0	3.3	3.4	3.7	3.2
6-31	3.7	3.8	3.6	3.7	3.6	--	3.6
6-32	3.9	3.3	3.5	--	3.3	3.6	3.3
6-33	3.9	3.7	3.9	3.6	3.5	3.6	3.6
6-34	3.8	3.9	3.4	3.7	3.8	3.4	3.5
6-35	3.5	3.2	3.6	3.7	3.6	3.3	3.3
6-36	3.5	3.6	3.3	3.5	3.5	3.3	3.5
6-37	3.7	3.8	3.6	3.7	3.6	3.5	3.2
6-38	3.4	3.2	3.4	3.7	3.2	--	3.2
6-39	3.5	4.0	3.3	3.7	4.1	--	3.5
6-40	3.8	3.2	3.4	3.4	3.4	3.2	3.4
6-41	3.7	3.4	3.4	3.9	3.5	3.6	3.2
6-42	3.6	3.2	3.6	--	3.6	--	3.7

THESE DATA WOULD INDICATE THAT MOISTURE PICKUP DURING THE SHELF LIFE STUDY WAS MINIMAL AND THAT BOTH POUCH CONSTRUCTIONS AFFORDED ADEQUATE PROTECTION. ADDITIONAL DATA ON MOISTURE STABILITY ON A QUARTERLY BASIS ARE INCLUDED AS PART OF THE INFORMATION GIVEN IN THE GENERAL TASTE PANEL STUDY.

THE FAT CONTENT OF THE DRY POWDERS WAS DETERMINED BY THE MOJONNIER METHOD[17]. THE TESTS INDICATED THAT ALL PRODUCTS WERE WITHIN THE DESIGN OF THE PROJECT. THESE DATA ARE LOCATED IN TABLE 4.

[16] METHODS OF ANALYSIS OF MILK AND ITS PRODUCTS, MILK INDUSTRY FOUNDATION, WASHINGTON, D.C. 3RD EDITION, 1959. PAGES 302-3.

[17] IBID. PAGE 273

THE FREE FAT WAS DETERMINED BY EXTRACTION WITH PETROLEUM ETHER AND INITIAL RESULTS ARE INCLUDED IN TABLES 3 AND 4. THIS TEST WAS ALSO RUN AT THE END OF THE 9-MONTH CONTROLLED STORAGE AT ALL TEMPERATURES AND TABLE 3 INDICATES THAT THERE WERE ONLY SLIGHT CHANGES IN FAT MIGRATION WITH RESPECT TO ANY OF THE STUDIED VARIABLES. THESE VARIATIONS ARE IN ALL PROBABILITY WITHIN THE ACCURACY OF THE TEST.

TABLE 3

FREE FAT INITIALLY AND AT THE END OF 9 MONTHS' CONTROLLED STORAGE

CODE	INITIAL	- -9TH MONTH- - - - 18°C	28°C	38°C
6-31	6.19	--	5.00	--
6-32	5.87	5.61	5.28	--
6-33	6.05	--	5.62	--
6-34	7.74	6.61	6.94	7.22
6-35	7.54	6.29	6.82	7.32
6-36	5.43	5.49	5.37	5.96
6-37	5.36	5.64	5.78	6.31
6-38	5.06	5.17	5.59	5.95
6-39	5.37	5.87	4.58	6.20
6-40	6.36	6.44	6.25	5.71
6-41	6.07	5.69	5.68	5.00
6-42	6.75	5.85	5.88	--

THE PROTEIN CONTENT OF THE DRY POWDERS WAS DETERMINED BY AOAC METHOD 16.150. THESE DATA LOCATED IN TABLE 4 WOULD INDICATE THAT ALL PRODUCTS HAVE ACCEPTABLE PROTEIN LEVELS.

THE ASH CONTENT OF THE DRY POWDER WAS DETERMINED BY AOAC METHOD 16.153. THESE DATA LOCATED IN TABLE 4 CAN BE CONSIDERED TYPICAL FOR A MILK PRODUCT IN THIS CATEGORY.

THE CALCULATED CALORIC VALUE WAS DETERMINED BY THE ATWATER METHOD IN WHICH PROTEIN AND CARBOHYDRATE ARE ASSIGNED A VALUE OF 4 AND FAT IS GIVEN A VALUE OF 9. THE CALORIC CONTENT IS SHOWN IN TABLE 4.

PROTEIN, ASH, AND CALORIC VALUES ARE CONSIDERED COMPARABLE TO THAT OF FORTIFIED 2% MILK AS IT APPEARS IN THE USDA HANDBOOK #8.

THE IODINE VALUE FOR EACH OF THE FAT SYSTEMS WAS CONDUCTED USING AOAC METHOD 28.019; RESULTS ARE ILLUSTRATED IN TABLE 4. THESE VALUES INDICATE A MUCH HIGHER DEGREE OF UNSATURATION IN THE DOMESTIC OIL (KAOMEL) THAN IN EITHER THE COCONUT OIL (HYDROL 92) OR THE PALM KERNEL OIL (PARAMOUNT X). THIS WOULD FURTHER INDICATE THAT THE DOMESTIC OIL SYSTEM SHOULD BE LESS STABLE ON STORAGE.

THE PROTEIN EFFICIENCY RATIO STUDIES FOR SELECTED STORED VARIABLES WERE CONDUCTED BY AN OUTSIDE LABORATORY[18]. THESE TESTS WERE DESIGNED TO DEMONSTRATE THE DIFFERENCES BETWEEN FAT SOURCE AND PROCESSING CONDITIONS. THE RESULTS ADJUSTED TO STANDARD 2.5 CASEIN ARE IN TABLE 4 AND INDICATE AN ACCEPTABLE PER FOR ALL VARIABLES.

TABLE 4

INITIAL PRODUCT COMPOSITION

CODE	% FAT	% FREE FAT	% MOISTURE	% PROTEIN	%* CARBOHYDRATE	% ASH	I VALUE	CALORIES/ 100 GM	PER
6-31	15.80	6.19	3.72	29.42	43.97	7.10	4.86	436	2.38
6-32	15.81	5.87	3.88	29.10	44.27	6.94	4.89	430	2.35
6-33	15.86	6.05	3.94	29.22	44.02	6.96	4.31	436	2.58
6-34	15.68	7.74	3.84	29.14	44.34	7.00	4.87	435	--
6-35	15.87	7.54	3.50	29.36	44.25	7.01	4.05	437	2.27
6-36	15.19	5.43	3.46	29.38	44.89	7.09	45.56	435	2.45
6-37	15.19	5.36	3.74	29.40	44.07	7.00	45.49	436	--
6-38	15.17	5.06	3.36	29.54	44.78	7.15	1.12	433	2.44
6-39	16.02	5.37	3.46	29.18	44.22	7.11	4.30	438	--
6-40	15.25	6.36	3.84	28.61	45.40	6.90	5.18	433	2.47
6-41	15.30	6.07	3.66	29.22	44.82	7.00	5.30	434	--
6-42	15.22	6.75	3.60	28.93	44.48	6.77	4.49	435	--

*BY DIFFERENCE

THE EVIDENCE OF OXIDATIVE AND BROWNING CHANGES WAS DETERMINED ORGANOLEPTICALLY AND VISUALLY INITIALLY AND AT MONTHLY INTERVALS FOR ALL PRODUCTS ON CONTROLLED STORAGE. EVIDENCE OF OXIDATION WAS EVALUATED IN THE DRY FORM BY SMELLING THE PRODUCT AND RATING ITS FRESHNESS. THE SAMPLE WAS THEN RECONSTITUTED AND TASTED. EVIDENCE OF BROWNING WAS DETERMINED BY OBSERVING BOTH THE DRY AND LIQUID PRODUCTS UNDER "NATURAL" TYPE FLUORESCENT LIGHTING. THIS METHOD WAS CHOSEN AS COLORIMETRIC METHODS IN PAST EXPERIENCE HAVE NOT BEEN ACCURATE ENOUGH TO PICK UP SUBTLE DIFFERENCES. THESE TESTS INDICATED THAT NO OXIDATION OR BROWNING WAS PRESENT INITIALLY, DURING, OR AT THE END OF THE CONTROLLED STORAGE PERIOD. THIS WAS TRUE FOR BOTH POUCH SYSTEMS AT ALL STORAGE TEMPERATURES.

[18]ROSNER-HIXSON LABORATORIES, CHICAGO, ILLINOIS

DRY PRODUCT CAKING EXISTED TO SOME EXTENT IN ALL STORED PRODUCTS AS STORAGE STUDIES PROGRESSED. THIS WAS OBSERVED IN ABOUT THE SIXTH MONTH OF STORAGE. AS CAN BE NOTED IN TABLE 5, THE CAKING INCREASED IN INTENSITY WITH BOTH TIME AND TEMPERATURE. THE CONDITION APPEARED TO BE DUE TO PRESSURE RATHER THAN MOISTURE SINCE AS INDICATED EARLIER IN TABLE 2, MOISTURE PICKUP WAS NEGLIGIBLE. CAKING DUE TO MOISTURE CAN RENDER A PRODUCT UNACCEPTABLE BY MAKING IT VERY DIFFICULT TO RECONSTITUTE. CAKING DUE TO PRESSURE, ALTHOUGH UNDESIRABLE FROM AN AESTHETIC STANDPOINT, DOES NOT APPRECIABLY INTERFERE WITH RECONSTITUTION. PRODUCT EXHIBITED A HARD CAKE AFTER SEVEN MONTHS' STORAGE AT 38°C; HOWEVER, ONLY MODERATE CAKE WAS PRESENT AFTER SIX MONTHS' STORAGE AT 38°C AND NINE MONTHS' STORAGE AT 28°C.

TABLE 5

CAKING DURING NINE MONTHS' CONTROLLED STORAGE

		Months @18°C						Months @28°C						Months @38°C					
Code	Initial	3	4	6	7	8	9	3	4	6	7	8	9	3	4	6	7	8	9
4-19	0	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	2	3	3
4-20	0	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	0	3	3
4-21	0	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	0	2	3
4-22	0	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	0	2	3
4-23	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	3
4-24	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	3	3
5-25	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
5-26	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
5-27	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
5-28	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
5-29	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
5-30	0	0	0	1	1	1	2	0	0	1	1	1	2	0	0	2	3	3	3
6-31	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-32	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-33	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-34	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-35	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-36	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-37	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-38	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-39	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-40	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-41	0	0	0	1	1	1	2	0	0	1	1	2	2	0	0	2	3	3	3
6-42	0	0	0	1	1	1	2	0	0	1	1	1	2	0	0	2	3	3	3

0 = NONE 1 = SLIGHT 2 = MODERATE 3 = HARD

RECONSTITUTION AND FOAMING TRENDS WERE STUDIED BY RECONSTITUTING THE DRY POWDER AS PREVIOUSLY DESCRIBED. THE TIME REQUIRED FOR DISPERSION AS WELL AS THE AMOUNT OF FOAM IN 1/32 INCH IS RECORDED IN TABLE 6. THE RATE OF RECONSTITUTION INDICATES THAT ALL SAMPLES RECONSTITUTED WELL WITHIN THE 5-MINUTE MAXIMUM SET FORTH IN THE OBJECTIVES. THE AMOUNT OF FOAM IN 1/32 INCH, I.E., THE SECOND NUMBER IN EACH COLUMN, INDICATES THAT ALTHOUGH THE AMOUNT OF FOAM DID VARY WITH FORMULATION AND PROCESS, VIRTUALLY ALL SAMPLES EXHIBITED AN EXCESSIVE FOAMING TENDENCY. NEITHER RECONSTITUTION RATE NOR THE AMOUNT OF FOAM APPEARED TO BE A FUNCTION OF STORAGE TIME OR TEMPERATURE.

THE FLAVOR OF ALL STORED PRODUCT WAS MONITORED AT MONTHLY INTERVALS DURING THE 9-MONTH STORAGE STUDY. TEST PRODUCTS FOR THESE EVALUATIONS WERE RECONSTITUTED AND THE FLAVOR WAS SCORED ACCORDING TO THE PROCEDURE DESCRIBED IN SERIES 2. THE RESULTS OF THESE EVALUATIONS ARE REPORTED IN TABLE 7.

THESE DATA WOULD INDICATE THAT (1) THE MAJORITY OF STORED SAMPLES HAD CONSTANT FLAVOR SCORES THROUGHOUT THE STORAGE STUDY AT 18° AND 28°C. THE 38°C SAMPLES MAINTAINED STABLE FLAVOR VALUES FOR SIX MONTHS WITH SOME DETERIORATION AFTER THAT POINT; (2) SLIGHT OFF FLAVORS WERE NOTED WITH RESPECT TO THE FORMULA ADDITIVES IN THE INITIAL EVALUATIONS WITH THIS SITUATION DISSIPATING EARLY IN THE STORAGE STUDIES; (3) THERE IS SOME INDICATION BASED ON THESE EVALUATIONS THAT THE FLAVOR OF THE 18° AND 28°C SAMPLES IMPROVED ON STORAGE FOR THE FIRST THREE OR FOUR MONTHS - THIS CONDITION WAS MAINTAINED UNTIL THE END OF THE STUDY; AND (4) THE PACKAGING SYSTEM WITHOUT THE OXYGEN SCAVENGER WAS COMPARABLE TO THE SCAVENGER POUCH FOR PHYSICAL AND FLAVOR CHARACTERISTICS TESTED.

TABLE 6

POWDER RECONSTITUTION TIME AND FOAM MEASUREMENT DURING NINE MONTHS' CONTROLLED STORAGE

		----- Months @ 18°C ----			---- Months @ 28°C -----			----- Months @ 38°C ----		
Code	Initial	3	6	9	3	6	9	3	6	9
4-18	60/8	60/8	60/4	60/2	60/8	60/4	60/2	60/8	60/4	60/2
4-19	60/2	45/2	60/2	60/1	45/2	60/2	60/1	45/2	60/2	60/1
4-20	30/4	60/4	60/4	60/2	60/4	60/4	60/2	60/4	60/4	60/2
4-21	90/4	45/4	60/2	60/2	45/4	60/2	50/2	45/4	60/2	60/2
4-22	60/2	30/2	60/2	60/1	30/2	60/2	60/1	30/2	60/2	60/1
4-23	30/1	15/1	15/2	15/2	15/1	15/2	15/2	15/1	30/2	30/2
4-24	60/2	15/2	30/2	30/2	15/2	45/2	30/2	15/2	45/4	45/2
5-25	30/2	30/2	30/2	15/4	30/2	30/2	15/4	30/2	30/2	45/4
5-26	30/2	30/2	30/2	15/2	30/2	30/2	15/2	30/2	30/2	15/2
5-27	30/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2
5-28	45/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	30/2
5-29	30/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2
5-30	30/2	30/1	30/2	15/2	30/1	30/2	15/2	30/1	30/2	15/2
6-31	20/4	15/2	20/2	15/2	15/2	20/2	15/2	15/2	20/2	30/2
6-32	20/4	15/2	20/2	15/2	15/2	20/2	15/2	15/2	20/2	30/2
6-33	20/4	30/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2
6-34	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2
6-35	15/2	15/1	15/2	15/2	15/1	15/2	15/2	15/1	15/2	15/2
6-36	40/4	30/2	30/2	15/4	30/2	30/2	15/4	30/2	30/2	15/4
6-37	20/4	30/2	30/2	15/4	30/2	30/2	15/4	30/2	45/4	30/4
6-38	30/4	45/2	45/4	30/4	45/2	45/4	30/4	45/2	45/4	30/4
6-39	30/4	30/2	30/4	30/2	30/2	30/4	20/2	30/2	30/4	20/2
6-40	20/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2
6-41	15/2	15/2	15/2	15/2	15/2	15/2	15/2	15/2	20/2	15/2
6-42	15/2	15/2	30/2	15/2	15/2	30/2	15/2	15/2	30/2	15/2

Data recorded as time in seconds over amount of foam in 1/32"

TABLE 7

HEDONIC FLAVOR STUDY DURING NINE MONTHS' CONTROLLED STORAGE

		Months																	
		3			4			6			7			8			9		
Code	Initial	18°	28°	38°	18°	28°	38°	18°	28°	38°	18°	28°	38°	18°	28°	38°	18°	28°	38°
4-18	6.0*	---	---	---	---	---	---	5.0	5.0	4.5	5.0	5.0	4.5	5.0	5.0	4.0	5.5	4.5	4.0
4-19	6.0	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	4.0	4.5	4.5	4.0	5.0	4.5	4.0
4-20	6.0	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.0	4.5	5.0	5.0	4.5	5.0	4.5	4.5	5.0	4.5	4.0
4-21	6.0*	5.0	5.0	5.0	5.5	5.5	5.5	6.0	5.5	4.5	6.0	5.5	5.0	5.0	4.5	4.0	5.0	4.5	4.0
4-22	6.0*	5.0	5.0	4.5	4.5	4.5	4.5	5.0	5.5	4.5	4.5	5.0	4.0	5.0	5.0	4.5	5.0	4.5	4.0
4-23	5.5*	5.0	5.5	5.5	5.0	5.0	5.0	5.0	4.5	4.0	5.0	5.0	4.5	5.5	5.0	4.0	5.0	4.5	4.5
4-24	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	4.5	6.0	5.5	4.5	6.0	5.5	4.0	5.5	5.0	4.5
5-25	6.0	6.0	6.0	5.0	6.0	6.0	5.5	6.0	5.5	5.0	6.0	5.5	4.5	6.0	5.5	4.5	6.0	5.5	4.5
5-26	6.0	6.0	6.0	6.0	---	---	---	6.0	5.5	5.0	6.0	5.5	5.0	6.0	5.5	4.0	6.0	5.5	4.5
5-27	6.0	6.0	6.0	5.5	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.0	5.5	5.5	5.0	4.0	6.0	5.5	5.0
5-28	6.0*	5.0	5.0	4.5	6.0	6.0	5.5	6.0	5.5	5.0	6.0	5.5	5.0	5.5	5.0	4.5	5.5	5.0	4.5
5-29	6.0*	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0	5.0	6.0	6.0	5.0	6.0	5.5	4.0	6.0	6.0	5.5
5-30	6.0*	4.0	4.0	5.0	5.5	6.0	6.0	6.5	6.5	6.0	6.0	6.0	5.5	6.0	6.0	5.5	6.0	6.0	5.5
6-31	6.0****	6.0	6.0	6.0	6.0	6.0	5.5	5.5	6.5	5.0	6.0	6.0	5.0	6.0	6.0	5.0	6.0	6.0	5.5
6-32	6.0*	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	6.0	6.0	5.0	6.0	6.0	5.0	6.0	6.0	5.5
6-33	6.0*	6.0	6.0	6.0	6.0	6.0	6.0	5.5	6.0	5.0	6.0	6.0	5.0	6.0	6.0	5.0	6.0	6.0	5.5
6-34	4.5*	6.0	6.0	5.5	6.0	6.0	6.0	5.5	6.0	6.0	5.5	5.5	5.0	5.0	5.5	4.5	5.5	5.5	4.5
6-35	5.0*	6.0	6.0	5.5	6.0	6.0	6.0	5.5	6.0	5.0	5.5	6.0	5.0	5.5	5.5	4.5	5.5	5.5	4.5
6-36	4.0	6.0	5.0	5.0	6.0	6.0	6.0	5.5	6.0	5.5	5.5	6.0	5.5	5.5	5.5	4.5	6.0	5.5	5.0
6-37	4.5	5.5	5.5	5.0	6.0	6.0	5.5	5.0	5.5	4.5	6.0	6.0	5.0	5.5	5.5	4.5	6.0	5.5	5.0
6-38	5.0	5.5	5.5	5.0	5.5	5.5	5.0	5.5	6.0	5.5	5.5	6.0	6.0	5.5	5.0	4.5	6.0	6.0	5.5
6-39	5.5	6.0	6.0	6.0	---	---	---	5.5	6.0	5.0	6.0	6.0	5.5	5.5	5.0	4.5	6.0	5.5	5.0
6-40	5.0**	6.0	6.0	6.0	6.0	6.0	5.5	6.0	6.0	5.5	6.0	6.0	5.0	6.0	6.0	5.0	5.5	6.0	5.5
6-41	5.0***	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0	5.5	6.0	6.0	5.5	5.5	6.0	5.0	6.0	6.0	5.5
6-42	5.5***	5.5	5.5	5.5	6.0	6.0	6.0	6.0	6.5	5.0	6.5	6.5	5.0	6.0	6.0	5.0	6.0	6.0	5.0

*SLIGHT LECITHIN **SLIGHT VANILLIN ***SLIGHT ARTIFICIAL ****HEATED FLAVOR

FLAVOR EVALUATIONS

These studies employed the use of an expert and general taste panel initially and at three-month intervals for a period of nine months to evaluate the control, fresh 2.0% market milk, and selected samples of the shelf life study. This information combined with the analytical, physical, and flavor data was used to determine the most satisfactory product of the storage program.

The expert taste panel was comprised of three to five persons familiar with dry milk products. The panel was used primarily to judge overall product flavor with emphasis on the presence of chalkiness.

The milk samples for the initial tests were reconstituted with 4.0°C water to yield 13.0% total solids with 2.0% fat. The serving temperature at the end of five minutes was approximately 15°C. The samples were evaluated for chalkiness at the 5 and 30 minute time intervals after reconstitution. At the same time they were rated on a 9-point Hedonic scale.

After analysis of this test, the initial general taste panel, and optimum total solids level screening studies, it was determined that a reconstitution level of 11.0 to 12.0% total solids should be used for all remaining studies. This level more closely matched the flavor and mouthfeel of the fresh 2.0% market milk.

It was further determined after contacting U.S. Army Natick Laboratories that a quality scoring form more suitable to milk products should be used to evaluate the remaining milk samples. This form included the following format:

1. Extremely poor
2. Very poor
3. Poor
4. Below fair - above poor
5. Fair
6. Below good - above fair
7. Good
8. Very good
9. Excellent

In all remaining expert evaluations the samples were reconstituted to 11.5% total solids according to the procedure described in the initial test and used the revised scoring system. The data in Table 8 include these scores combined with that of a blind 2.0% milk sample. Initial scores for flavor are recorded for all series 6 variables. In order to sharpen the focus of the study, a number of samples were eliminated after the initial evaluation. Based on flavor, stability, and solubility data, samples containing Kaomel and Paramount X as well as those instantized with steam were not included in the subsequent expert panels.

The data in Table 8 demonstrate that the products tested had acceptable flavor scores throughout the test period when compared to fresh 2.0% market milk. Chalkiness was not considered a problem as panelists did not detect its presence in any of the test products.

TABLE 8

AVERAGE HEDONIC SCORES FOR EXPERT TASTE PANEL DURING NINE MONTHS' CONTROLLED STORAGE

DATE RECORDED 5 MINUTES / 30 MINUTES

CODE	INITIAL	3 MONTHS 18°C	3 MONTHS 28°C	3 MONTHS 38°C	6 MONTHS 18°C	6 MONTHS 28°C	6 MONTHS 38°C	9 MONTHS 18°C	9 MONTHS 28°C	9 MONTHS 38°C
6-31	5.0	5.8 / 5.5	5.7 / 5.7	5.7 / 5.5	6.7 / 6.6	6.5 / 6.6	6.0 / 6.0	5.6 / 6.0	5.0 / 5.3	5.0 / 5.0
6-32	5.3	5.6 / 5.7	5.5 / 5.9	5.0 / 5.4	4.7 / 4.7	5.7 / 5.6	4.0 / 4.5	--	--	--
6-33	5.6	5.4 / 5.4	5.4 / 5.2	4.5 / 5.0	5.3 / 5.0	5.0 / 5.0	4.0 / 4.5	5.3 / 6.2	5.[illegible] / 6.0	4.5 / 5.0
6-34	5.5	--	--	--	--	--	--	--	--	--
6-35	5.8	--	--	--	--	--	--	--	--	--
6-36	5.3	--	--	--	--	--	--	--	--	--
6-37	5.7	--	--	--	--	--	--	--	--	--
6-38	5.3	--	--	--	--	--	--	--	--	--
6-39	4.9	--	--	--	--	--	--	--	--	--
6-40	5.7	--	--	--	--	--	--	--	--	--
6-41	5.3	--	--	--	--	--	--	--	--	--
6-42	--	--	6.2 / 6.0	--	--	7.2 / 7.0	--	5.6 / 5.5	6.5 / 6.2	--
2% MARKET MILK	6.3	--	6.7 / 6.3	--	--	7.0 / 6.9	--	--	7.0 / 7.0	--

THE GENERAL TASTE PANEL WAS DESIGNED WITH DATA FROM THE EXPERT PANEL TO YIELD THE MOST PROMISING PRODUCT OF THE CONTROLLED STORAGE PROGRAM. THESE TESTS WERE CONDUCTED USING APPROXIMATELY 30 YOUNG ADULT MALE STUDENTS OF GREENVILLE COLLEGE RANGING IN AGE FROM 18 TO 25 YEARS. THE MILK SAMPLES FOR THESE TESTS WERE PREPARED WITH 4.0°C. WATER AND PLACED IN INSULATED CONTAINERS PRIOR TO TESTING. AT THE TIME OF TESTING, SAMPLES WERE 30 MINUTES TO 60 MINUTES OLD AND HAD TEMPERATURES RANGING FROM 10°C. TO 15°C.

AS DISCUSSED IN THE OBJECTIVES OF THIS PROJECT, THE PERCENT FAT[19], PERCENT TOTAL SOLIDS[20], AND PERCENT INSOLUBLE NONFAT SOLIDS[21], WERE REQUIRED FOR ALL TEST PRODUCT. THESE DATA APPEAR IN THE TABLES GIVING THE GENERAL TASTE PANEL RESULTS. FOR FURTHER CLARITY OF THE TASTE PANEL DATA, THE HOMOGENIZATION EFFICIENCY AND DRY MOISTURE CONTENT OF EACH SAMPLE WAS ALSO INCLUDED.

A DETAILED DISCUSSION OF EACH GENERAL TASTE PANEL FOLLOWS.

THE INITIAL GENERAL TASTE PANEL WAS CONDUCTED IN THE BASEMENT OF THE FIRST BAPTIST CHURCH. TO MINIMIZE TALKING AND DISCUSSION OF THE TEST PRODUCTS, THE PANELISTS WERE SEATED FOUR TO AN 8-FOOT TABLE FACING OUTWARD. THE TABLES WERE LOCATED IN A LARGE SEMI-CIRCLE APPROXIMATELY 10 FEET APART. THE TEST SAMPLES WERE RECONSTITUTED TO 13.0% TOTAL SOLIDS AND 2.0% FAT AND DISTRIBUTED FROM THE CENTER OF THE SEMI-CIRCLE IN NUMBER-DESIGNATED PAPER CUPS. THE PANEL WAS DIVIDED INTO TWO TASTING SESSIONS OF SIX SAMPLES EACH WITH FRESH MARKET 2.0% MILK INCLUDED AS THE UNMARKED CONTROL. IN THIS PANEL THE 9-POINT SCORING SYSTEM PREVIOUSLY DISCUSSED IN THE INITIAL EXPERT PANEL WAS USED AND THE DATA COLLECTED ARE AS FOLLOWS:

TABLE 9

INITIAL GENERAL TASTE PANEL
(29 PANELISTS)

CODE	STORAGE TEMP.°C.	HEDONIC AVERAGE	% FAT	% TOTAL SOLIDS	% UNDISSOLVED NONFAT SOLIDS	HOMO EFFICIENCY	% DRY MOISTURE
6-31	INITIAL	3.0	2.04	12.75	.15	POOR	3.72
6-32	INITIAL	2.9	2.15	13.17	.10	POOR	3.88
6-33	INITIAL	3.?	2.08	12.84	.15	POOR	3.94
6-34	INITIAL	3.1	1.99	12.54	.95	POOR	3.84
6-35	INITIAL	2.9	2.03	12.59	1.00	POOR	3.50
6-36	INITIAL	2.3	2.18	13.18	.10	GOOD	3.46
6-37	INITIAL	2.8	2.10	13.00	.15	GOOD	3.74
6-38	INITIAL	2.1	2.06	12.85	.10	GOOD	3.36
6-39	INITIAL	2.6	--	---	.25	--	3.46
6-42	INITIAL	3.0	2.09	13.07	.10	GOOD	3.60
2% MARKET MILK		5.6	1.85	10.63	--	POOR	--

[19]METHODS OF ANALYSIS OF MILK AND ITS PRODUCTS, MILK INDUSTRY FOUNDATION, WASHINGTON, D. C. 3RD EDITION, 1959. PAGE 273
[20]IBID. PAGE 287
[21]IBID. PAGES 476-7

THESE DATA DEMONSTRATED THAT ALL FLAVOR SCORES INCLUDING THE FRESH MARKET 2.0% MILK WERE UNREALISTICALLY LOW. BASED ON THE REASONING DISCUSSED IN THE EXPERT TASTE PANEL IT WAS DECIDED TO REDUCE THE TOTAL SOLIDS OF THE RECONSTITUTED SAMPLES AND USE THE SCORE CARD RECOMMENDED BY THE NATICK LABORATORIES IN ALL REMAINING GENERAL TASTE PANEL STUDIES.

EVEN THOUGH THE FLAVOR SCORES WERE CONSIDERED LOW, THEY DID INDICATE THAT THE HYDROL 92 VARIABLES WERE PREFERRED OVER THE PRODUCTS CONTAINING PARAMOUNT X AND KAOMEL OIL SYSTEMS. THE HYDROL 92 SERIES WAS USED IN THE REMAINING GENERAL TASTE PANEL STUDIES. COMPARATIVE DATA FOR THE OTHER OIL SYSTEMS CAN BE FOUND IN TABLE 7.

THE PERCENT TOTAL SOLIDS AND PERCENT FAT DATA INDICATE THAT ALL PRODUCTS WERE RECONSTITUTED WITHIN THE DESIRED RANGE. THE 2.0% MARKET MILK HAD LOWER VALUES THAN EXPECTED. THIS SITUATION MAY HAVE CAUSED SOME OF THE DISCREPANCIES IN THIS PANEL. THE PERCENT UNDISSOLVED NONFAT SOLIDS WAS CONSIDERED VERY GOOD FOR ALL SAMPLES TESTED WITH THE EXCEPTION OF THE STEAM INSTANTIZED VARIABLES. THESE LEVELS, APPROXIMATELY 1.0%, WERE CONSIDERED TOO HIGH AND THESE VARIABLES WERE ELIMINATED FROM FUTURE EVALUATION IN THE GENERAL TASTE PANEL. RELATIVE FLAVOR SCORES FOR THESE VARIABLES OVER THE CONTROLLED STORAGE PERIOD ARE INCLUDED IN TABLE 7.

THE PERCENT MOISTURE OF THE DRY PRODUCT AND HOMOGENIZATION EFFICIENCY OF THE LIQUID PRODUCT HAVE BEEN INCLUDED AS GENERAL INFORMATION WITH NO DEFINITE TRENDS ESTABLISHED FOR THE HOMOGENIZATION EFFICIENCY AT THIS TIME. THE PERCENT DRY MOISTURES INDICATED ALL PRODUCT WAS IN AN ACCEPTABLE RANGE PRIOR TO TESTING.

THE 3-MONTH GENERAL TASTE PANEL WAS CONDUCTED ACCORDING TO THE FORMAT ESTABLISHED IN THE INITIAL PANEL AND WAS DESIGNED TO EVALUATE THE HYDROL 92 VARIABLES AT THEIR CONTROLLED STORAGE TEMPERATURES. THESE RESULTS ARE INCLUDED IN THE FOLLOWING TABLE.

TABLE 10

3-MONTH GENERAL TASTE PANEL
(32 PANELISTS)

CODE	STORAGE TEMP. °C	HEDONIC AVERAGE	% FAT	% TOTAL SOLIDS	% UNDISSOLVED NONFAT SOLIDS	HOMO EFFICIENCY	% DRY MOISTURE
6-31	18°C	3.9	1.63	10.52	.10	GOOD	--
6-31	28°C	3.9	1.64	10.95	.10	GOOD	--
6-31	38°C	3.2	1.70	10.83	.10	GOOD	--
6-32	18°C	3.9	1.83	11.14	.10	GOOD	--
6-32	28°C	4.9	1.83	11.20	.10	GOOD	--
6-32	38°C	4.7	1.75	10.93	.10	FAIR	--
6-33	18°C	4.5	1.54	10.19	.10	POOR	--
6-33	28°C	5.1	1.73	10.90	.10	FAIR	--
6-33	38°C	4.0	1.55	10.57	.10	FAIR	--
6-42	28°C	4.8	1.55	10.59	.10	FAIR	--
2% MARKET MILK		5.3	1.93	10.79	--	--	--

THE HEDONIC AVERAGES WOULD INDICATE THAT THE NEW SCORING SYSTEM HAD AIDED IN GIVING MORE REALISTIC VALUES TO THE PRODUCTS BEING TESTED. THE FRESH MARKET MILK CONTROL, HOWEVER, WAS NOT AFFECTED AND RECEIVED APPROXIMATELY THE SAME SCORE AS IT DID IN THE INITIAL EVALUATION. AFTER THREE MONTHS' STORAGE THE SAMPLES STORED AT 28°C APPEARED TO HAVE THE BEST FLAVOR WITH THE 18°C AND 38°C VALUES BEING SLIGHTLY LOWER. ALL SAMPLES SCORED WITHIN 2.0 POINTS OF THE CONTROL.

THE PERCENT TOTAL SOLIDS AND PERCENT FAT VALUES FOR THIS STUDY WERE LOWER THAN ANTICIPATED BUT DID NOT APPEAR TO AFFECT THE FLAVOR RATINGS OF THE TEST PRODUCT.

THE UNDISSOLVED NONFAT WAS CONSIDERED TO BE ACCEPTABLE AND CONSTANT FOR ALL PRODUCTS WITH NO DETERIORATION IN THIS CHARACTERISTIC AT ANY OF THE STORAGE TEMPERATURES. HOMOGENIZATION EFFICIENCIES HAD NOT BEEN AFFECTED BY STORAGE TEMPERATURE AND WERE CONSIDERED COMPARABLE WITH THE RESULTS OBTAINED IN THE INITIAL PANEL.

THE 6-MONTH GENERAL PANEL WAS A CONTINUATION OF THE 3-MONTH PANEL AND WAS DESIGNED TO FURTHER EVALUATE THOSE SAMPLES WITH AN ADDITIONAL THREE MONTHS' CONTROLLED STORAGE. THE FOLLOWING ARE THE RESULTS OBTAINED FOR THESE TESTS.

TABLE 11

6-MONTH GENERAL TASTE PANEL

CODE	STORAGE TEMP. °C	HEDONIC AVERAGE	% FAT	% TOTAL SOLIDS	% UNDISSOLVED NONFAT SOLIDS	HOMO EFFICIENCY	% DRY MOISTURE
6-31	18°C	3.5	1.93	12.14	.08	GOOD	3.52
6-31	28°C	3.7	1.90	12.11	.08	GOOD	4.00
6-31	38°C	2.5	1.95	12.04	.13	GOOD	4.00
6-32	18°C	3.8	1.98	12.04	.05	GOOD	3.48
6-32	28°C	4.5	1.92	11.92	.05	GOOD	3.80
6-32	38°C	3.5	1.94	12.08	.08	GOOD	4.00
6-33	18°C	5.0	1.92	11.77	.08	GOOD	3.72
6-33	28°C	4.0	1.91	11.73	.10	GOOD	3.72
6-33	38°C	3.3	1.93	12.08	.10	GOOD	4.00
6-42	28°C	4.0	1.90	12.05	.10	FAIR	3.40
2% MARKET MILK		5.5	2.00	10.88	--	--	--

THESE DATA WOULD INDICATE THAT ALL ANALYTICAL AND PHYSICAL CHARACTERISTICS ARE NORMAL AND WITHIN ACCEPTABLE RANGES WITH NO DEFINITE TREND ESTABLISHED WITH RESPECT TO STORAGE AND TEMPERATURE VARIATIONS. THE FLAVOR SCORES INDICATE THAT THE SAMPLE CODED 6-33 IS THE BEST VARIABLE ON STORAGE AND COMPARES FAVORABLY WITH THE CONTROL. THE SAMPLES CODED 6-31 AND 6-32 HAVE RECEIVED SLIGHTLY LOWER FLAVOR SCORES AND ARE CONSIDERED COMPARABLE IN FLAVOR VALUES.

AT THIS POINT IN THE INVESTIGATION A DEFINITE TREND WAS ESTABLISHED WITH RESPECT TO FLAVOR DETERIORATION AND STORAGE TEMPERATURES. THE 18°C AND 28°C SAMPLES WERE DEFINITELY SUPERIOR TO THE 38°C PRODUCT. THE SAMPLE MODIFIED WITH FLAVOR ADDITIVES, 6-42, WAS STILL CONSIDERED ACCEPTABLE BUT DID INDICATE A LOWER FLAVOR VALUE. THIS WOULD INDICATE THAT THIS MODIFICATION DID NOT PROLONG THE SHELF LIFE AS EXPECTED.

THE 9-MONTH GENERAL TASTE PANEL WAS CONDUCTED ACCORDING TO THE METHODS ESTABLISHED FOR THE THREE PRECEDING PANELS AND WAS DESIGNED TO EVALUATE THE FOLLOWING SAMPLES AS A MEANS OF DETERMINING THE BEST PRODUCT OF THIS STUDY.

6-33 AT 18°, 28°, AND 38°C WAS CHOSEN AS IT CONSISTENTLY SCORED WELL THROUGHOUT THE ENTIRE PROGRAM.

6-31 AT 18°, 28°, AND 38°C WAS SELECTED BASED ON DIRECTION FROM THE PREVIOUS EXPERT AND GENERAL TASTE PANELS WHICH INDICATED A CLEANER FLAVOR CHARACTER.

6-42 AT 18° AND 28°C WAS CHOSEN AS FURTHER DATA WERE DESIRED WITH RESPECT TO STORAGE STABILITY AND FLAVOR ADDITIVES.

THIS PANEL DID NOT INCLUDE THE 6-32 VARIABLE AS OFF NOTES WERE DETECTED IN THE PREVIOUS EXPERT PANEL. ALSO, IT WAS DECIDED TO REDUCE THE WORK LOAD OF THE PANELISTS FOR GREATER ACCURACY IN THE FINAL TEST. THE PANEL EVALUATED TWO LOTS OF FIVE SAMPLES EACH AND THE FOLLOWING ARE THE RESULTS OBTAINED.

TABLE 12

9-MONTH GENERAL TASTE PANEL
(38 PANELISTS)

CODE	STORAGE TEMP. °C	HEDONIC AVERAGE	% FAT	% TOTAL SOLIDS	% UNDISSOLVED NONFAT SOLIDS	HOMO EFFICIENCY	% DRY MOISTURE
6-31	18	4.7	1.87	11.40	0 1	POOR	3.84
6-31	28	4.1	1.82	11.34	0.1	POOR	3.64
6-31	38	3.5	1.82	11.38	0.1	FAIR	3.68
6-33	18	5.0	1.87	11.39	0.1	POOR	3.72
6-33	28	4.6	1.80	11.20	0.1	VERY POOR	3.92
6-33	38	3.8	1.81	11.21	0.1	POOR	3.60
6-42	18	4.8	1.77	11.34	0.1	POOR	3.68
6-42	28	4.1	1.76	11.39	0.1	FAIR	3.80
2% MARKET MILK		6.0	1.96	10.80	--	POOR	--

BASED ON THESE DATA THE SAMPLE CODED 6-33 WAS CONSIDERED TO BE THE MOST PROMISING product developed. IT MAINTAINED AN ACCEPTABLE SHELF LIFE DURING THE CONTROLLED STORAGE STUDY FOR NINE MONTHS AT 18°C AND 28°C, AND FOR SIX MONTHS AT 38°C. ALSO, IN ALL STATED TIME PERIODS THIS PRODUCT'S HEDONIC AVERAGES WERE WITHIN 2.0 POINTS OF THE CONTROL FRESH MARKET 2.0% MILK.

THE PRODUCT CODED 6-31 WAS ALSO CONSIDERED ACCEPTABLE WITH SLIGHTLY LOWER SCORES THROUGHOUT THE DURATION OF THE STUDY.

AS BEFORE, THE SAMPLE 6-42 CONTAINING THE FLAVOR ADDITIVE DID NOT EXHIBIT ANY FLAVOR IMPROVEMENT WITH RESPECT TO THE OTHER PRODUCTS TESTED AND WAS CONSIDERED COMPARABLE TO 6-31.

RECOMMENDED PROCESSING PROCEDURE AND FORMULATION

CODE 6-33

1. RAW SKIM MILK TESTING 8.6% TOTAL SOLIDS WAS PREHEATED TO 180°F WITH A 15 SECOND HOLD PRIOR TO THE VACUUM PAN AND FLASHED INTO THE VACUUM PAN OPERATING AT 26" AND 120°F. IT WAS CONDENSED TO 35.18% TOTAL SOLIDS AND 0.25% FAT.

2. THE CONDENSED SKIM WAS MIXED WITH THE FAT SYSTEM TO YIELD A DRY POWDER CONTAINING 15.5% FAT. THE OIL USED FOR THIS MIXTURE WAS HYDROL 92 CONTAINING ATMOS 150 AND TENOX A AT 7.14% AND 0.05% OF THE FAT SYSTEM, RESPECTIVELY.

3. ALL COMPONENTS WERE HEATED TO 150°F PRIOR TO MIXING. THIS MIXTURE WAS MIXED FOR 5 MINUTES, PLATE HEATED TO 180°F, FLASHED INTO VACUUM CHAMBER OPERATING AT 15" VACUUM. AFTER THE VACUUM TREATMENT, THE MIX WAS REMOVED FROM THE CHAMBER AT 160°F AND HOMOGENIZED AT 3000 + 500 PSIG AND COOLED TO 40°F PRIOR TO SPRAY DRYING. TESTS INDICATED "GOOD" HOMOGENIZATION EFFICIENCY AT THIS POINT IN THE PROCESS.

4. THE MIX WAS SPRAY DRIED AT 365°F INLET TEMPERATURE WITH A 195°F EXHAUST TEMPERATURE USING AN SC-35 HIGH PRESSURE NOZZLE OPERATING AT 2300 PSIG. THE RESULTANT DRY POWDER WAS COOLED TO 90°F, AND HAD A DRY MOISTURE CONTENT OF 3.6% AND A DENSITY OF 0.58 GM/CC.

5. THE DRY POWDER WAS PREBLENDED WITH 2.0% SEED LACTOSE AND 0.125% SILICON DIOXIDE AND WAS INSTANTIZED FOLLOWING THE WATER INSTANTIZING PROCEDURE USING DSS AND LECITHIN AS REHYDRATION AIDS. THESE ADDITIVES WERE ADDED AT A RATE CALCULATED TO BE 0.003% AND 0.007%, RESPECTIVELY, OF THE RECONSTITUTED MILK PRODUCT. THE AGGLOMERATED POWDER HAD 16.5% MOISTURE CONTENT OUT OF THE HYDRATION CHAMBER AND ACHIEVED LACTOSE CONVERSION WITH 1.0 MINUTE HOLD ON AN ENDLESS BELT PRIOR TO REDRYING. THE AGGLOMERATED MAT WAS THEN CHOPPED WITH A WIRE CUTTER AND REDRIED TO 3.0% MOISTURE CONTENT ON A TRAY DRYER OPERATING AT 290°F AND 260°F FOR THE FIRST AND SECOND SECTIONS, RESPECTIVELY. THE DRY INSTANTIZED POWDER WAS THEN TRAY COOLED TO 70°F.

THE FORMULATION OF THE DRY INSTANTIZED MILK PRODUCT WAS:

COMPONENT	%
SKIM MILK SOLIDS	79.280
MILK FAT (ESTIMATED)	0.575
VEGETABLE OIL	13.836
EMULSIFIER	1.106
ANTIOXIDANT	0.008
LACTOSE	2.000
SILICON DIOXIDE	0.125
DSS	0.020
LECITHIN	0.050
MOISTURE	3.000

THIS PRODUCT WAS DESIGNED TO BE RECONSTITUTED WITH 10-15°F WATER AND TO YIELD A MILK DRINK CONTAINING 11.5% TOTAL SOLIDS AND 1.8% FAT.

ONE-HALF KG OF THIS PRODUCT WAS FORWARDED TO THE CONTRACTING OFFICER.

CONCLUSION AND RECOMMENDATIONS

FROM THE DATA DEVELOPED DURING THE COURSE OF THIS STUDY IT DOES APPEAR FEASIBLE TO PROVIDE A DRY WHOLE MILK SUBSTITUTE FOR RATION USE.

THE FORMULATION AND PROCESS DEVELOPED YIELDS A PRODUCT WHICH RECONSTITUTES SATISFACTORILY AND DOES NOT EXHIBIT THE CHALKY FLAVOR PREVIOUSLY ENCOUNTERED IN PRODUCTS OF THIS TYPE.

PRODUCT PRODUCED BY A COMMERCIALLY FEASIBLE PROCESS DOES MEET THE GENERAL REQUIREMENTS ESTABLISHED IN THE OBJECTIVES OF THIS STUDY.

IT WOULD APPEAR THAT ADDITIONAL PRODUCT REFINEMENT MAY BE DESIRABLE TO:

1. ELIMINATE THE FOAMING CHARACTERISTIC OF THE RECONSTITUTED PRODUCT.
2. UPGRADE FLAVOR THROUGH FURTHER STUDY OF FLAVOR ADJUNCTS AND POTENTIATORS.
3. REDUCE THE CAKING TENDENCY OF STORED PRODUCT.