TECHNICAL REPORT
NATICK/TR-92/049

AD _____

LABORATORY AND CONSUMER EVALUATIONS OF ALTERNATIVE FORMULATIONS OF RECOMBINED MILK

by
Kathryn Rock
Andre Senecal
F. Matthew Kramer
Alan Bennett
Nancy J. Kelley

September 1992

Final Report
October 1990 - September 1991

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

SOLDIER SCIENCE DIRECTORATE

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1992	Final, Oct 90 - Sept 91

4. TITLE AND SUBTITLE

Laboratory and Consumer Evaluations of Alternative Formulations of Recombined Milk

5. FUNDING NUMBERS

PE: 1L263001DC07
PR: DC07
TA: BB
WU: F00
Ag Code: MSR 1559

6. AUTHOR(S)

Kathryn Rock, Andre Senecal, F. Matthew Kramer, Alan Bennett
Nancy J. Kelley

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Natick Research, Development and Engineering Center
Natick, Ma 01760-5020

8. PERFORMING ORGANIZATION REPORT NUMBER

NATICK/TR- 92/049

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release, distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Fresh milk is not available for distribution to military facilities in countries outside the continental United States. The use of recombined filled milk was implemented as an alternative. Filled milk is made up of water, nonfat dry milk and coconut or canola oil. Due to research and an increase in public awareness and concern about health, the use of tropical oils is being reduced and the military has supported research into alternative fat sources for filled milk.

In October 1991, a four-day study comparing five different milk formulations: canola oil with mono & diglycerides, canola oil with actoloid, canola/sunflower blend, sunflower oil, and coconut oil, was conducted on the island of Okinawa, Japan. Air Force and Marine personnel and their dependents volunteered from commissaries, military dining halls, and a high school. Each person was served two different milk samples with a questionnaire. The questionnaire asked for demographic information and requested ratings on overall milk acceptability, milk flavor, milk consistency, and milk mouthfeel. All possible pairs of milk samples were served in random, counterbalanced order. Milk filled with coconut oil received the highest rating; however, it will not be used because of health concerns. The milk filled with sunflower oil typically received the highest rating of the remaining four samples, and the two samples filled with canola oil received the lowest ratings.

14. SUBJECT TERMS					15. NUMBER OF PAGES
RECOMBINED FILLED MILK	CONSUMERS	TEST AND EVALUATION			21
FATS	EMULSION	PRODUCTION			16. PRICE CODE
	MILK	ACCEPTABILITY	FAT SUBSTITUTES		

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

TABLE OF CONTENTS

LIST OF TABLES

PREFACE

The objective of this study was to provide technical and consumer data as a basis for choosing the filled milk product to be produced at the Government-owned, contractor operated (GOCO) milk plants at overseas locations. Development and testing of alternative formulations for filled milk were required due to health concerns about the use of saturated fats in the most common currently produced product. The field test was conducted on the island of Okinawa, Japan by the Behavioral Sciences Branch, Soldier Science Directorate, and the Food Technology Division, Food Engineering Directorate of U.S. Army Natick Research, Development and Engineering Center.

The authors are indebted to many individuals and organizations for their contributions to this project. CPT Andy Whisnant, chief of Food Management of the 18th SVS Kadena Air Force Base (AB), played a critical role in the field execution of this study. His support and coordination of several major requirements of the study ensured its completion. The production of the milk samples would not have been possible without the guidance and assistance of Mr. Ron Turnbow, manager of the GOCO Makiminato Milk Plant at Camp Kinser. The value of their assistance with this test cannot be overemphasized.

The implementation of this study included the use of dining facilities, commissaries and a high school. It was necessary to rearrange portions of these facilities and interrupt daily scheduling in order to obtain proper testing conditions. We would like to thank the following people for their cooperation and patience: CPT Macniel, Commissary Manager at Camp Foster; MSG Reyes, Manager of Camp Foster Mess Hall 488; GYSGT Martinez, from Camp Foster Mess Hall; MSG Sluss, Manager of Camp Futemna Mess Hall 423; GYSGT Pope of Camp Futemna Mess Hall 423; TSG Davis, NCOIC of Marshal Dining Hall, Kadena AB; SGT Eck of the Marshall Dining Hall, Kadena AB; SSG Slater NCOIC of Strickland Dining Facility, Kadena AB; Mr. Hill, Manager of the Kadena AB Commissary; Dr. Apkarian Principal of Kadena High School; Ms. Smith, Vice-Principal of Kadena Middle School; and Ms. Satorius, school lunch manager at Kadena AB.

We want to thank SGTs Whitfield and Davis of the 18th SVS who contributed to the field test with undying assistance. SSG Anderson of the ration breakdown on Kadena AB made special arrangements to store the milk there and enabled us to get access when necessary.

We also want to express our appreciation to LTC Deborah Page for her assistance with the test site location and coordination efforts. Finally, for his assistance with the test design and statistical analysis, we would like to thank Larry Lesher.

LABORATORY AND CONSUMER EVALUATIONS OF ALTERNATIVE FORMULATIONS OF RECOMBINED FILLED MILK

INTRODUCTION

Fresh milk is not available for distribution to military facilities in countries outside the continental United States (OCONUS). In these countries, dairy herds and milk processing plants do not meet the U.S. sanitary standards. The cost and practicality of shipping fresh milk to these countries made it necessary to find an alternative to fresh milk. Powdered milk was used until the 1950s when recombined "filled" milk was implemented as an alternative for fresh milk. The ingredients for recombined filled milk are sent to overseas locations and the milk is produced at GOCO milk plants. It is produced by combining water, nonfat dry milk (NDM) and canola or coconut oil, blending at 120-140 °F (48.9-60 °C) , followed by high-temperature, short-time (HTST) pasteurization and homogenization.

The Quartermaster Food and Container Institute for the Armed Forces supported research during the late 1940s and the 1950s at several universities to improve dry, whole milk (McIntire, 1955). The problems associated with dry, whole milk include loss of flavor quality during manufacture and storage and the difficulty of dispersion in water (Coulter et al., 1957). Milk fat was diagnosed as the principal source of the dry, whole-milk flavor problem. Testing of other oils, including coconut, hydrogenated coconut, hydrogenated cottonseed, peanut, lard, and soybean, proved coconut oil produces a superior filled milk product (McIntire, 1955; Patton et al., 1959). Coconut oil has since replaced milk fat in filled milk produced at GOCO overseas milk plants.

Research in the 1980's has shown that a high dietary intake of saturated fats is associated with high blood cholesterol and coronary heart disease (Oliver, 1990). Coconut oil is high in saturated fat (92%) and therefore its use has been scrutinized by the office of The Surgeon General as well as other health organizations. These factors and increased public awareness and concern about health have led to reduced use of such tropical oils in selected foods at the consumer level and the military to support research into alternative fat sources for filled milk.

The fats used in filled milks produced at military GOCO milk plants must be stable over a wide range of temperatures and variable lengths of storage. These fats must also possess sensory and functional properties capable of producing characteristics of milk products. These restrictions have resulted in the choice of partially hydrogenated fats high in monounsaturation as candidates for coconut fat replacement in military milk products.

METHODOLOGY

Development of Oil/Emulsifier Test Systems

The oil/emulsifier test systems, chosen as potential replacements for coconut oil in filled milk, resulted from extensive studies in the storage stability of commercially available monounsaturated oils and the sensory acceptability of the oil/emulsifier combinations. A study was conducted by A.G. Senecal, C.B Read, B.A. Nelson, and B.B. Bennett at the US Army Natick Research, Development and Engineering Center during 1989 to 1991 to determine if the commercial alternative oils could withstand exposure to the adverse storage conditions characteristic for these products. A second study was contracted to Kansas State University (Jeon, et al., 1992) to develop the optimum least-saturated oil or blend for use in filled milk, utilizing the same commercially available oils. The oils chosen for these studies were highly stable monounsaturated oils possessing minimum active oxygen methods (AOM) of 100 to 200 hours. The oils used in the initial studies are listed in Table 1. All oils were partially hydrogenated for increased stability.

TABLE 1
OILS USED IN INITIAL STUDIES

Oil	Commercial Source
Soybean	Anderson Clayton/Humko, Memphis, TN
Canola	Anderson Clayton/Humko, Memphis, TN
Coconut (Control)	Anderson Clayton/Humko, Memphis, TN
Cottonseed (Duromel)	Van den Berg Foods, Strongsville, OH
Cottonseed/Soybean (Kaomel)	Van den Berg Foods, Strongsville, OH
High-Oleic Sunflower*	SVO Enterprise, Eastlake, OH

*High-oleic sunflower oils include Trisun HB 95, Trisun HB 105, Trisun HS 100, and Trisun HS 500.

The in-house storage stability study consisted of exposing the oils to temperatures of 40 °, 80 ° and 100 °F (4.4 °, 26.7 ° and 37.8 °C) for six months. Samples were removed monthly and tested for AOM stability, fatty acid profile, color and sensory quality. Sensory and color analysis were conducted with whole filled milk (3.25% fat).

Results from the chemical analysis suggested that all fats were relatively stable to oxidation under these storage conditions. Temperature and time in storage had no significant effect on color, nutritional quality or AOM stability. Sensory analysis of recombined, filled milk was the most useful index for determining stability and acceptability of these vegetable fats. Even though

rancidity had no effect on flavor, sensory analysis indicated that storage may have resulted in the production of off flavors characteristic of the oils' origin. Canola and high-oleic sunflower (HB105) oils were found to be the closest to coconut oil for storage stability.

The purpose of the Kansas State University contract was to investigate the effect of partially hydrogenated vegetable oils and emulsifier/stabilizers on the flavor and textural qualities of filled milk and to identify oils that are comparable to coconut oil in acceptability. To achieve these objectives, eight oils were tested in all possible combinations with three emulsifiers/stabilizer systems and one emulsifier without stabilizer. The emulsifier formulations are listed in Table 2. Sensory results from an expert milk panel indicated that the formulations of Canola/Actoloid D22B, High-Oleic Sunflower HB95/Actoloid D22A and a 50:50 blend of these two systems were not significantly different from coconut oil or each other. Because the size of the panel was small ($n = 6$), they were unable to establish statistical significance although considerable differences in mean sensory scores were observed. Therefore, the test systems that performed best in the Kansas State study and oils that had passed the in-house storage test were chosen for the user test.

TABLE 2
EMULSIFIER FORMULATIONS

Emulsifier/stabilizer	Formulation
Mono- & Diglycerides	Mixture of mono- and diglyceride flakes.
Actoloid D22A	Mono- and diglycerides, sodium casinate, soy protein, carrageenin, and sodium citrate.
Actoloid D22B	Mono- and diglycerides, soy protein, whey protein, carrageenin, sodium citrate, and disodium phosphate.
Actoloid D22C	Mono- and diglycerides, sodium caseinate, carrageenin, and sodium citrate.

The Actoloid emulsifier/stabilizers were obtained from Advance Food System, Inc. (Somerset, NJ).

The mono- and diglycerides mixture was obtained from Anderson Clayton/Humko Products, Inc. (Memphis, TN).

Test Subjects

Air Force and Marine Corps personnel along with their dependents located in Okinawa, Japan were surveyed to get a representation of all populations familiar with recombined filled milk.

Test Sites and Procedures

Air Force and Marine commissaries, dining halls, and a high school were used as data collection sites. In the dining halls data were collected during lunch meals because that time of day provided the largest number of possible participants. The test booth was set up inside the

doorways in order to survey the soldiers before they ate their meal. The test time was limited to the dining hall's hours of operation. In the commissaries the tests began at 1000 and continued until approximately 200 people were surveyed. The test booth was set up next to the store milk display. In the high school the test also ran during the lunch period. The test booth was set up along the lunch waiting line where students were approached before they received their meal. Table 3 shows the number of people surveyed at each site.

TABLE 3
TEST SITES

	N
Air Force Bases	
Kadena Commissary	180
Strickland Dining Hall	121
Marshal Dining Hall	112
Kadena High School	63
Marine Bases	
Foster Commissary	193
Foster Dining Hall	133
Futemna Dining Hall	96
TOTAL	898

Milk Production

The filled milk samples for this test were produced at the GOCO milk plant, located at the Makiminato Service Area, Makiminato, Okinawa. Dairy Maid Dairy, Inc. was the contractor operating the milk plant, which provides filled milk products to all the military installations on Okinawa. The milk samples were produced at this facility using the same processes and equipment used in the daily milk production. This reduced the possibility of introducing any variables into the product quality and particularly the flavor.

The formula for each of the samples is shown in Table 4. Sample A was the fat/emulsifier system currently used by the Okinawa GOCO milk plant to replace coconut fat in filled milk. For the purpose of this test, Dairy Maid Dairy's milk from the same day of production as the alternative milks was used. The pasteurizing temperature and homogenization pressure was the same as for the other four formulations. The nonfat dry milk powder used in all the formulations was U.S. Extra Grade, U.S. Low Heat Nonfat Dry Milk, coded 3 Sep 1990 (one year old at the time of use).

A 200 gallon batch size was determined to be the minimum but adequate amount to be run through the 3500 gal/h HTST pasteurizing system, product lines, holding tanks, and filler to obtain a good representative sample for each formulation. Each batch was formulated so that finished

products met the requirements of whole milk with a minimum of 3.25% fat, 8.25% nonfat milk solids and 11.50% total solids. Each batch was carefully monitored and followed by complete flushing and draining of the tanks, lines, pasteurizer, and filler before starting a new batch.

TABLE 4
FORMULATION OF THE SAMPLES IN GRAMS

INGREDIENTS	A	B	C	D	E
Canola oil w/mono & diglycerides	57.6				
Canola oil wo/mono & diglycerides		57.6		28.8	
Sunflower oil - Trisun HB 9			57.6	28.8	
Coconut oil					57.6
Nonfat Dry Milk	149.6	149.6	149.6	149.6	149.6
Actoloid					
D22A			5.2	2.6	
D22B		5.2		2.6	
Water	1512.8	1512.8	1512.8	1512.8	1512.8
Total Weight	1720.0	1725.2	1725.2	1725.2	1720.0

To reduce the introduction of confounding variables, the process used in manufacturing the filled milks was the same for each batch. The first step was to weigh out all the ingredients. Solid fats were melted using the fat melt tank system. The resulting liquid oils were weighed out into clean containers and held at 95-100 °F (35-37.8 °C) until transferred into the oil supply tank of the HTST system for each formulation. Actoloid stabilizers for formulas B, C, and D were weighed out and thoroughly mixed with an aliquot of the nonfat dry milk (NDM) to ensure uniform distribution through the blending system. The filtered water for each batch was measured into the blending tanks using the standpipe method. The premeasured amount of water was pumped through the in-line dry ingredient blender to mix the NDM and dry stabilizers as applicable with water. During the blending procedure, the operator slowly added the NDM/Actoloid stabilizer premix with the balance of the milk powder to ensure complete dispersion and good rehydration of the stabilizers. The blended nonfat milk was heated to 145 °F (62.8 °C) in the raw regenerator section of the APV Crepaco Inc. HTST unit. Just prior to the homogenizer, the liquid oil was metered into the heated nonfat milk. The filled milk was homogenized in a Crepaco two-stage homogenizer operating at 2000 psig (1500/500 psig), then pasteurized at 172±2 °F (77.8±1.1 °C), cooled to 48 °F (8.9 °C), and pumped into refrigerated holding tanks. Each batch was filled into

1/2 pint Pure-Pak milk cartons using an Excello Pure Pak OP model filler. Between each batch, the lines, pumps and filler were thoroughly rinsed and drained to ensure complete batch segregation. The filled containers were cased, marked, and placed into a 35 °F (1.7 °C) cold storage box where the filled milk samples were held for 12 hours. The samples were transferred to the cold storage facility at Kadena AB by refrigerated truck, where they were held at 35 °F (1.7 °C) until delivered daily to the respective test sites.

Test Design

Participants were served one-ounce samples of two different milks (Table 5) with a three-ounce glass of water. The milk was served in white plastic cups, one sample was marked with an "X" on the outside of the cup and the other one was blank. They were instructed to drink the milk in the cup marked with the "X" first and rate the sample using nine-point rating scales (Peryam et al., 1957) then rinse with water before drinking and rating the second sample using similar scales. While sampling the milk, the participants were either standing or sitting at tables made available to them. The participants were not aware of which samples they were drinking. All possible pairs of milk samples were served in random, counterbalanced order. See Appendix for the questionnaire.

TABLE 5
MILK SAMPLES USED IN FIELD TEST

Sample A	Canola oil with mono & diglycerides (present milk type produced in Okinawa)
Sample B	Canola oil with Actoloid D22B
Sample C	Sunflower oil (Trisun HB95) with Actoloid D22A
Sample D	Canola oil/Sunflower oil (50:50 blend) with Actoloid D22A/D22B
Sample E	Coconut oil (standard GOCO milk product)

Measurements

The questionnaire asked the participants to provide demographic information including age, sex and length of time in countries that serve filled milk. There were four questions regarding the milk: overall acceptability, milk flavor, consistency, and mouthfeel. The first sample was rated on the front of the sheet and the second sample was rated on the back of the same sheet to minimize, as much as possible, comparison of milk ratings. The last question on the form asked the participants to choose which of the two milks they preferred.

Data Analysis

A one-way analysis of variance (ANOVA) was used to test for significant differences between the mean ratings. Significant ANOVA's were followed by a Student-Newman-Keuls (SNK) post

hoc test to determine differences between pairs of mean ratings. The criterion level of statistical significance was set at .05 for the ANOVA and post hoc comparisons.

Demographics

Air Force and Marine Corps personnel along with their dependents (N = 898) participated in the study. There were 605 males and 283 females (10 respondents did not answer this question) with an average age of 26.2 years and ranging from 8 to 70 years. Overall, the participants from Foster Commissary and Kadena Commissary were significantly older than the participants from the other testing sites while participants from Kadena High School were significantly younger (Table 6).

RESULTS

Background Information

A one-way ANOVA revealed no significant differences between the mean milk ratings for the different age groups. For statistical analysis ages were arranged into four groups (8-18 years, 19-24, 25-30, over 30). On the background information portion of the questionnaire the participants were asked how long they had been in Japan or other countries that serve filled milk. Table 6 shows the distribution of time in years by site. Although the subjects from Foster Commissary, Kadena Commissary, and Kadena High School had been in these countries a significantly longer time than the subjects from the other five testing sites, time was not a factor in explaining the differences between milk sample ratings. Factors such as age, length of time in Japan, and milk intake were not factors in explaining the differences between milk sample ratings. Therefore, results that are reported here are for the entire sample.

TABLE 6
AGE AND YEARS IN JAPAN OR OTHER COUNTRIES SERVING FILLED MILK

	MEAN AGE	AGE RANGE	TIME IN YEARS
Air Force Bases			
Kadena High School	16.0	13-43	3.59
Kadena Commissary	31.0	8-70	3.58
Strickland Dining Hall	27.6	19-45	2.20
Marshal Dining Hall	22.8	18-44	1.29
Marine Bases			
Foster Commissary	31.4	9-70	3.64
Foster Dining Hall	22.6	18-47	.78
Futemna Dining Hall	20.7	18-39	.68

Acceptability

The acceptability of the milk was rated using a nine-point hedonic scale (1 = "Dislike Extremely", 9 = "Like Extremely"). Table 7 shows the number of participants who rated each milk type (N), the mean acceptability rating (MEAN), and the standard deviation (SD). The filled milk with coconut oil, received the highest acceptability rating. An ANOVA found the acceptability ratings of the five milk samples were not all the same ($F_{4,1788} = 7.11$, $p \leq .05$). A post-hoc test revealed that the milk with coconut oil was rated significantly higher than the two milks containing canola oil and higher than the milk filled with the canola/sunflower blend. The milk made with the sunflower oil was rated significantly higher than both canola oil milks; no significant difference appeared between the sunflower oil milk and the coconut oil milk. An ANOVA found no significant difference between the ratings received in the dining halls and those received in the commissaries. For statistical analysis, Kadena High School was categorized as a dining hall. Overall, males rated the milk acceptability higher than the females, although relationship between gender and milk is not dependent upon the sample of milk tested. Additionally there was no significant difference in acceptability ratings of the samples between Air Force and the Marines personnel.

TABLE 7

MEAN ACCEPTABILITY RATINGS OF THE FIVE MILK SAMPLES

	N	MEAN	SD
Coconut oil	359	5.81	1.95
Sunflower oil	357	5.56	2.01
Canola oil/Sunflower oil Blend	357	5.40	1.99
Canola oil with Actoloid D22B	359	5.19	1.99
Canola oil with Mono-diglycerides	361	5.12	2.03

Flavor

Table 8 shows the number of participants who rated milk flavor on each milk, the mean rating, and the standard deviation. A nine-point scale (1 = very poor, 9 = very good) was used to evaluate the milk flavor. An ANOVA found the flavor ratings of the five milk samples were not all the same ($F_{4,1790} = 4.43$, $p \leq .05$). The coconut oil filled milk was rated significantly higher than both milks filled with the canola oil and higher than the milk filled with the canola/sunflower blend. The sunflower oil milk was also rated significantly higher than the milk containing canola oil with mono- and diglycerides. Again, no significant difference occurred between the coconut oil milk and sunflower oil milk.

TABLE 8
SUMMARY OF MILK FLAVOR RATINGS

	N	MEAN	SD
Coconut oil	359	5.67	2.11
Sunflower oil	359	5.39	2.11
Canola oil/Sunflower oil Blend	357	5.33	2.03
Canola oil with Actoloid D22B	359	5.14	2.00
Canola oil with Mono-diglycerides	361	5.09	2.09

Consistency

Table 9 shows the number of people who rated consistency, the mean rating, and the standard deviation of each milk separately. These results are based on a nine-point hedonic scale with anchors of 1 = Watery and 9 = Thick. An ANOVA found the consistency ratings of the five milk samples were not all the same ($F_{4,1789} = 4.54$, $p \leq .05$). The sunflower oil filled milk received the highest rating but was not significantly higher than the coconut oil milk. Both the coconut and sunflower oil milks were rated significantly higher than the two milks filled with canola oil.

TABLE 9
SUMMARY OF MILK CONSISTENCY RATINGS

	N	MEAN	SD
Coconut oil	359	5.41	1.83
Sunflower oil	359	5.47	1.80
Canola oil/Sunflower oil Blend	357	5.29	1.81
Canola oil with Actoloid D22B	358	5.05	1.80
Canola oil with Mono-diglycerides	361	5.03	1.81

Mouthfeel

A nine-point hedonic scale with anchors of 1 = Chalky and 9 = Oily was used to rate mouthfeel. Table 10 shows the number of people that rated mouthfeel, the mean rating, and the standard deviation. An ANOVA found the mouthfeel ratings of the five milk samples were not all the same ($F_{4,1786} = 4.18$, $p \leq .05$). The mean rating of the filled milk with coconut oil was significantly higher than all the other samples tested.

TABLE 10
SUMMARY OF MILK MOUTHFEEL RATINGS

	N	MEAN	SD
Coconut oil	360	5.20	1.60
Sunflower oil	359	4.89	1.72
Canola oil/Sunflower oil Blend	354	4.90	1.72
Canola oil with Actoloid D22B	359	4.79	1.79
Canola oil with Mono-diglycerides	359	4.71	1.82

SUMMARY

The results of this study show that across the attributes assessed the milk filled with coconut oil was the most acceptable milk of the five samples tested. However, coconut oil filled milk will not be used because of health concerns. Milk filled with sunflower oil typically received the highest rating of the remaining four samples. Coconut oil filled milk and sunflower filled milk received similiar ratings for four of the five attributes evaluated, the only significant difference being the attribute mouthfeel. Based solely on consumer responses, sunflower oil filled milk would be the preferred choice. The two canola oil filled milks were clearly the least acceptable. Given that each milk was rated by approximately 360 individuals varying in age, sex, and military status, these results provide a reliable representation of the relevant milk-user populations. The differences between the milks are modest, however, so practical factors must also be incorporated in choosing which oil to use (e.g., cost, ease of handling, availability).

REFERENCES

Coulter, S.T., Jenness, R., Stine, C.M., Pyne, C.H. and Hobbs, W.E. Mechanism of deteriorative changes in milk products. Quartermaster Food and Container Institute for Armed Forces Technical Report D-305. 1957.

Jeon, I.J., Roberts, H.A. and Senecal, A.G. The replacement of coconut oils with unsaturated oils in recombined filled milk. Technical Report NATICK/In press. 1992.

McIntire, J.M. Review of quartermaster contract research work on flavor aspects of dry whole milk. Dry Milk Products-a Symposium ed McIntire, J.M., Stone, W.K. and Peterson, M.S. pp 7-16. Washington, D.C.: National Academy Of Sciences, 1955.

Oliver, M.F. Introduction: Lipids and coronary disease - resolved and unresolved problems. British Medical Journal 1990, 46 (4), 865-872.

Patton, S., Keeney, P.G., Thrap, B.W., and Parks, O.W. Dehydration of milk - Phase I. The origin of off-flavors which occur in dry milk during storage. Technical Report Quartermaster Food and Container Institute for Armed Forces/D-309. 1959.

Peryman, D.R. and Haynes, J.G. Hedonic scale methods of measuring food preferences. Food Technology 1990, 11(9), 9-14.

APPENDIX

APPENDIX

MILK QUESTIONNAIRE

Please provide us with the following background information.

1. Age (years)_____

2. Sex (circle one) Male Female

3. How long have you lived in Okinawa? _____ years _____ months

4. Have you lived in the Phillipines, Korea, or on other islands of Japan (circle one)?
   Yes No
   If yes, for how long? _____

5. How many glasses of milk do you drink (choose ONE of the following)?

   A. I usually drink milk every day (number of glasses _____).

   B. I usually drink milk every week (number of glasses _____).

   C. I usually drink milk every month (number of glasses _____).

6. Please rate your first milk on the following:

A. Overall Acceptability	1 Dislike Extremely	2	3	4	5	6	7	8	9 Like Extremely
B. Milk Flavor	1 Very Poor	2	3	4	5	6	7	8	9 Very Good
C. Consistency	1 Watery	2	3	4	5	6	7	8	9 Thick
D. Mouthfeel	1 Chalky	2	3	4	5	6	7	8	9 Oily

(OVER)

USAF SCN 91-60

7. Please rate your second milk on the following:

A. Overall Acceptability	1 Dislike Extremely	2	3	4	5	6	7	8	9 Like Extremely
B. Milk Flavor	1 Very Poor	2	3	4	5	6	7	8	9 Very Good
C. Consistency	1 Watery	2	3	4	5	6	7	8	9 Thick
D. Mouthfeel	1 Chalky	2	3	4	5	6	7	8	9 Oily

8. Which of the two milks do you prefer? (Circle One) 1st milk 2nd milk