LIPID VARIATIONS IN FILLED MILKS AND LIQUID COFFEE WHITENERS

by

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ABSTRACT

Although substitute or imitation products which simulate dairy products have been marketed for a long time, regulatory provisions covering standards of identity and labeling of these products vary widely. It might thus be assumed that certain compositional characteristics of these substitute or imitation products would also vary. This study was designed to observe variation in gross composition and fatty acid distribution in certain filled milk products during an observation period of six continuous months.

Single half-gallon containers of eight filled milks and pint or quart containers of four liquid coffee-whiteners were purchased on or about the first day of each month from June through November, 1969, in Central and Southern Arizona. Percents of total solids and fat were measured by standard methods and fatty acid distribution was determined by gas liquid chromatography.

The results showed significant variation in total solids and fat content not only between products from different manufacturers but also within products produced by individual processors. The fatty acid analyses showed two diverse fat types used in these products. One type was characterized by high levels of laurate, myristate, and

palmitate with a total saturated fatty acid content well over 90%. The second type was characterized by high levels of palmitate, oleiate, and linoleiate with a total unsaturated fatty acid content of 80% or more. The characteristic fatty acid distribution varied in some of the individual products from one type to the other during the course of the study.

INTRODUCTION

Substitute or imitation products which simulate dairy products have been on the market for a long time. However, only within the last decade have any of these products secured a significant portion of the fluid milk and cream market.

Some of the products which have achieved this incursion into the dairy producers' primary source of income are the non-dairy coffee-whiteners and the filled or imitation milk beverages. These products have attracted the most attention from the dairy industry since the introduction of margarine. They offer the American consumer comparable substitute foods of acceptable quality at substantially lower prices. These products have also reduced the market for dairy foods. Estimates of 15 to 35% of the fluid cream market has been taken over by the non-dairy coffee-whiteners in the last six to eight years (23, 36, 43).

More recently, the introduction of the filled or imitation beverages has created a significant impact on fluid milk sales. These filled or imitation beverages are now being marketed in at least 18 states, and in Arizona alone sales have reached as high as 11.5% of the total fluid Class I milk sales (Table 1). In the past 10 years the per capita milk sales in the United States has decreased 5½% (28). This alone is distressing to milk producers, but in addition, marketing specialists have predicted that producer prices could drop 10% if imitation or filled milk takes only 5% of the fluid milk market (17).

The reasons for the inroads in dairy product sales by these items have been attributed to extensive advertising, lower prices, acceptable taste and flavor, confusion with whole milk products, and assumed equal nutritional value of the natural dairy foods (14, 23, 51). The issues of product identity and nutritional value still remain to be resolved in many instances.

Legislation has been enacted or proposed to alleviate the confusion with the dairy products and also to ensure standards of identity and quality control. In most cases the imitation products contain skim milk with only the lipid constituent being substituted. There are no laws governing the type of fat or oil which may be used. Because of nutritional and other implications it is desirous to know something about the composition and variation of the fats and oils being added to the substitute products.

The objectives of this study were to evaluate the amount and variation in total solids and lipid composition

TABLE 1

AMOUNT OF PACKAGED CLASS I FILLED MILK PRODUCTS WHICH CONTAIN VEGETABLE FAT PROCESSED AND DISTRIBUTED BY HANDLERS UNDER U.S.D.A. FEDERAL ORDER 131

Year	1966		1967	
Month	Amount of product (lbs., X1000)	Proportion of total Class I (%)	Amount of product (lbs., X1000)	Proportion of total Class I (%)
January			691	2.0
February			769	2.4
March			945	2.7
April			894	2.8
May			964	2.9
June			933	3.1
July			989	3.2
August			1,185	3.8
September			1,392	4.1
October	438	1.3	1,547	4.5
November	597	1.8	1,598	4.6
December	626	1.8	1,700	5.1

TABLE 1, Continued

Year	1968		1969	
Month	Amount of product (lbs., X1000)	Proportion of total Class I (%)	Amount of product (lbs., X1000)	Proportion of total Class I (%)
January	1,872	5.3	3,931	10.4
February	2,293	6.8	3,500	10.3
March	2,779	7.8	3,676	9.9
April	2,841	8.3	3,181	8.9
May	3,129	8.9	2,874	7.9
June	3,094	9.9	2,147	6.7
July	3,478	10.8	1,963	6.2
August	3,812	11.5	1,717	5.4
September	3,609	10.7	1,549	4.3
October	3,765	10.4	1,480	3.9
November	3,560	10.2	1,145	3.5
December	3,669	10.8	1,137	3.1

Source: Market Information Bulletin, Central Arizona Marketing Area, Federal Order 131 (in 4).

of some of the substitute dairy products being sold in Arizona over a period of time. The relevance of this survey relates to the fact that these substitute products differ basically from dairy products by replacement of the natural milk fat with a vegetable fat or a combination of vegetable fats. Since dietary fat is the most concentrated biological source of energy and also a carrier of fat-soluble nutrients, possible nutritional and other implications could result from the replacement of one type of fat by another.

REVIEW OF LITERATURE

Recent surveys conducted in various states allowing the sale of filled milk products have shown their consumer acceptability to be based on several variables. Among these are: price, flavor, confusion with natural milk products, and assumed nutritional equality with the real dairy product (14, 23, 51). Price has usually been the primary attraction to the consumer. Surveys have indicated that the primary reason given for selection of a filled milk product was price in 36-78% of the cases, depending on the study (14, 23, 51). The basic reason for the reduction in cost is due to the replacement of animal fat with a less expensive vegetable fat or combination of vegetable fats. The processors of these vegetable fats have indicated the ingredient cost of a filled or imitation milk product to be approximately 14.9 cents per half-gallon while the cost for a half-gallon of the whole milk product is approximately 27.2 cents (36). It is estimated that the vegetable fat costs roughly 11 to 26 cents per pound as compared to approximately 80 to 83 cents per pound for butterfat (13, 41).

Because of the lower ingredient cost these filled milk products are sold in the market at a substantially lower price than the whole milk products. Price for the filled or imitation beverages in Arizona has varied from 29-45 cents per half-gallon as compared to 48-56 cents for whole milk (4). The liquid non-dairy coffee-whiteners prices ranged from 24-29 cents per pint while cream ranges between 45-49 cents per pint (35).

The American housewife has not only been able to take advantage of these prices, but the Department of Defense, by using hydrogenated vegetable fat rather than anhydrous butterfat in manufacturing certain milk products for overseas areas, saved $1.6 million in one fiscal year (3). The economics of these products has thus played a major role in securing an inroad into dairy product sales.

Acceptable flavor and taste has been a second factor contributing to the consumer demand of filled milk products. A number of situations have occurred in which competent, knowledgeable or trained individuals have not been able to distinguish these products from the dairy products by their gustatory characteristics (11, 15, 41). Surveys have shown that as high as 43% of those who purchased the product did so because they liked the flavor (23). All products of this type do not, however, possess this acceptable flavor and taste appeal. Some surveys have shown that half of those who quit buying these products did so because of taste or flavor (26). Although the organoleptic quality of these products has been good in some cases and below optimum in others it still is a major factor in the consideration of consumer acceptability.

Confusion, due to packaging and labeling, of the filled or imitation products with whole milk products is another reason attributed to the acceptability of these products. West (51) reported that 14% of those who purchased these products did so because of mistaking them for the whole dairy product counterpart due to confusion in packaging and labeling. The laws or regulations concerning the packaging and labeling of these products vary from state to state (38, 49). Some states require the word imitation to be printed on the carton while others do not. Some, but not all, of the states require specific ingredient composition to be shown on the carton. Because of these inconsistencies between states, a great deal of confusion has arisen as to product identity. Legislation has been proposed or enacted in many states to insure product identity. Since some of this legislation has been somewhat discriminatory, the filled or imitation product producers have contested the legality of these regulations (14). Legislation to protect the consumer from product confusion while at the same time not discriminating against the imitation or filled product producers is presently under discussion in many areas allowing the sale of these products.

In one study, nine to twenty-five percent of those who purchased the filled or imitation products did so because they considered the product to be equally as nutritional or possessing additional nutritional benefits compared to the dairy products (23). Adequate analyses with respect to the nutritional value of these filled and imitation products have not been performed. Since dairy products and filled or imitation products differ basically only by the types of fat they contain; it can be assumed that any significant nutritional differences would result from variations found in the fat constituent. Because of the nutritional implications of substituting vegetable fat for the naturally occurring animal fat, it is desirous to know the chemical composition of the fats and oils that are being used and to ascertain how much normal variation within a particular product might be expected.

In order to prevent confusion resulting from the varying terminology used to describe the substitute dairy products, their constituents will be defined before discussing any nutritional implications. The products concerned are liquid non-dairy coffee-whiteners, filled and imitation milk. The liquid non-dairy coffee-whiteners are generally composed of varying amounts of water, vegetable fat, soy protein or sodium caseinate, emulsifiers, stabilizers, buffering agents, flavorings, and coloring agents (36, 37).

There are two types of filled milks being produced. One is a combination of fluid skim milk, with or without skim milk solids, and a vegetable fat. The second type consists of water, nonfat dry milk, vegetable fat, and an additional source of protein such as soy protein or sodium caseinate. Variable amounts and types of vitamins may be added (6). The truly imitation or simulated milk is made with vegetable fat, a protein source (sodium caseinate, soy protein, whey protein), a carbohydrate source (corn syrup solids, lactose), an emulsifier, buffer salts, stabilizer, added vitamins and flavoring (23).

The emulsifiers used in the imitation or filled products consist of fatty acid esters such as sorbitan mono-stearate or polyoxyethylene sorbitan tri-stearate. The stabilizers normally are sodium citrate, tetrasodium pyrophosphate (sodium pyrophosphate), dipotassium phosphate, carrageenan, carboxymethyl cellulose, sodium alginate, and locust bean gum or guar gum. The bodying agents used are calcium caseinate, potassium caseinate, soybean proteinate, corn syrup solids, sucrose, and lactose (36).

As previously stated the main area for nutritional variation between the natural dairy product and the simulated product lies within their differing lipid makeup. The processing method and type of vegetable fat used in the substitute products have significant nutritional implications.

The vegetable fats used in the substitute products are often subjected to a partial hydrogenation process which converts the natural oils from a liquid to a plastic state at room temperature and increases their stability (40). The partial hydrogenation process that is employed results in four types of chemical changes: (1) The main type is a conversion of some of the polyunsaturated fatty acids to monounsaturated fatty acids, (2) The double bond may shift position along the carbon chain, producing isomeric acids, (3) The predominately _cis_ configuration may change to the _trans_ configuration, and (4) During hydrogenation of linoleic, linolenic, or arachidonic acids, double bonds may become conjugated, and thus are no longer separated by a methylene group.

The change from the natural _cis_ configuration to the _trans_ configuration has been shown to result in significant nutritional deficiencies. Milk fat usually contains 9-10% _trans_ acids (10) whereas hydrogenated vegetable fats have been shown to contain as high as 47% _trans_ acids (48). While the _trans_ fatty acids have been found to be digested and metabolized as easily as the _cis_ fatty acids (9), they differ in their ability to incorporate into triglycerides and phospholipids (32, 39, 42). They also seem to alter the permeability and transport functions of cell membranes (8, 12). In addition, trans isomers of the essential fatty acids lose their essential fatty acid activity (33). Finally, it has been stated by Keys (30) that the vegetable fats that undergo partial hydrogenation become biologically less desirable.

Vegetable fats, in general, have come to be equated with a high content of polyunsaturated fatty acids, which it is believed have a low cholesterol producing effect in the blood stream (6, 46). However, not all vegetable fats are high in polyunsaturated fatty acids. In fact, coconut oil, a vegetable fat often used in these substitute products, is characterized by a very high total saturated fatty acid content (Table 2). Coconut oil contains an appreciably high amount of lauric, myristic and palmitic acids which have been reported to have the greatest cholesterol promoting effect of any saturated fatty acids (2, 19, 20, 39). Studies have shown that diets containing substantial amounts of coconut oil result in significantly higher serum cholesterol levels (1, 27). It has also been demonstrated that coconut oil products have low growth promoting properties (45). Research has shown that infant diets which are high in coconut oil and thus low in essential fatty acids

TABLE 2

TYPICAL MAJOR FATTY ACID ANALYSES OF SOME FATS OF ANIMAL AND PLANT ORIGIN[a]

Fatty Acid	Saturated						
	4-8	Capric 10:0	Lauric 12:0	Myristic 14:0	Palmitic 16:0	Stearic 18:0	Arachidic 20:0
<u>Animal</u>							
Bovine Milk	5.5	3.0	3.5	12.0	28.0	13.0	
Human Milk		1.5	7.0	8.5	21.0	7.0	1.0
<u>Vegetable</u>							
Corn					12.5	2.5	0.5
Peanut					11.5	3.0	1.5
Cottonseed				1.0	26.0	3.0	
Soybean					11.5	4.0	
Olive					13.0	2.5	
Coconut	7.0	6.0	49.5	19.5	8.5	2.0	

TABLE 2, Continued

Fatty Acid	Unsaturated Palmitoleic 16:1	Oleic 18:1	Linoleic 18:2	Linolenic 18:3
Animal				
Bovine Milk	3.0	28.5	1.0	
Human Milk	2.5	36.0	7.0	1.5
Vegetable				
Corn		29.0	55.0	0.5
Peanut		53.0	26.0	
Cottonseed	1.0	17.5	51.5	
Soybean		24.5	53.0	7.0
Olive	1.0	74.0	9.0	0.5
Coconut		6.0	1.5	

[a] Composition is given in weight percentages of the component fatty acids (rounded to nearest 0.5) as determined by gas liquid chromatography (40)

may create an essential fatty acid deficiency resulting in skin lesions (21, 47). One study showed that intolerance and dyspepsia associated with poor growth and increased incidences of infections occurred in infants whose diets consisted of a coconut oil, evaporated filled milk diet (5). Finally, several laboratories have observed that calcium absorption is depressed when filled milk containing coconut oil is substituted for natural milk (44, 52).

Fat and oil suppliers are now producing a polyunsaturated fat which usually consists of a combination of soybean and cottonseed oil or other naturally occurring polyunsaturated vegetable oils (36). These oils have been shown to decrease serum cholesterol levels (2, 31, 34, 50). Polyunsaturated fats rich in essential fatty acids have, however, been shown to prolong clotting time of blood in comparison to fats rich in saturated fatty acids which shorten the clotting time (24). High amounts of polyunsaturated fatty acids in the diets of infants have also been shown to decrease their Vitamin E supply which is needed for its antioxidant capabilities (18, 22). Strong evidence indicates that large amounts of polyunsaturated fats in the diet may form peroxides with harmful consequences, that polymers may be formed which accentuate the aging process, and that the cholesterol and fat level of the liver may be raised (44). Finally, Holman (25) has stated that for optimal nutrition, a balance of saturated, unsaturated, and polyunsaturated fatty acids should be maintained. This balance is not found in the polyunsaturated vegetable oils (Table 2).

EXPERIMENTAL PROCEDURES AND TECHNIQUES

Eight filled milk and four liquid coffee-whitener products were surveyed once each month from June through November, 1969. Single half-gallon containers of filled milk and pints or quarts of liquid coffee-whiteners were purchased on or about the first of each month at retail food store outlets in Central and Southern Arizona. Immediately following purchase all products were packed in ice and upon arrival at the laboratory were refrigerated at approximately 2°C. Aliquots were taken from the products and analyzed for total solids and percent fat within 48 hours after purchase. Aliquots were taken and stored at approximately -10°C for subsequent analysis of fatty acids. Finally, additional aliquots were taken and stored at approximately -10°C to prevent total loss of sample in event of a laboratory accident or other need for reanalyzation. The composition of each product as stated on its carton is given in Table 3. Products A through H were filled milks and products 1 through 4 were liquid coffee-whiteners.

Total solids and fat were measured as a percentage on a weight basis. The determinations were done by the standard Mojonnier methods as described by Goss (16).

TABLE 3

PRODUCT COMPOSITION AS STATED ON CARTON

Filled Milks:

A. A pasteurized blend of Grade A fluid skim milk, vegetable fat, Grade A nonfat milk solids, mono and di-glycerides.

B. A pasteurized blend of fluid Grade A skim milk, hydrogenated vegetable fat, Grade A nonfat dry milk solids, mono and di-glycerides and carotene.

C. A pasteurized blend of Grade A fluid skim milk, vegetable oils, Grade A nonfat milk solids, mono and di-glycerides.

D. Grade A skim milk, Grade A milk solids nonfat, vegetable oil, mono and di-glycerides, artificial color.

E. A pasteurized blend of Grade A fluid skim milk, vegetable oil, Grade A nonfat milk solids, mono and di-glycerides.

F. Same as E.

G. A pasteurized blend of fluid skim milk, vegetable oil 3.5%, milk solids nonfat, mono and di-glycerides.

H. Reconstituted skim milk, vegetable fat, high in polyunsaturates, mono and di-glycerides, artificially colored with beta carotene.

Liquid Coffee Whiteners:

1. Water, hydrogenated vegetable oil, corn syrup, soya protein, carraseenan, sodium citrate, disodium phosphate, mono and di-glycerides, polysorbate 60, sorbitan monostearate, lecithin, salt, artificial flavor and color.

2. Water, vegetable oil, corn syrup solids, sodium caseinate, mono and di-glycerides, sodium citrate, salt, carrageen, phosphates, carotene and dextrose.

TABLE 3, Continued

3. Water, vegetable fat, sorbitol, sodium caseinate, glycerol, emulsifiers, stabilizer, sugar, di-potassium phosphate, salt, artificial flavor and color.

4. Water, hydrogenated vegetable fat, corn syrup solids, sodium caseinate, mono and di-glycerides, sodium citrate, salt, di-potassium phosphate, carrageenan, artificial color.

The aliquots for fatty acid analyses were removed from storage and placed in a refrigerator at about 2°C approximately 24 hours before analysis in order to thaw. The fat of the products was isolated by the TeSa fat test method (7). Approximately 0.2 gm. fat was dried under vacuum and the fatty acids were then converted to their methyl esters by transmethylation, using sodium methoxide (7). The methyl esters were extracted in hexane and approximately 1.5 ul. of the mixture were injected directly into a Perkin-Elmer Model 800 gas chromatograph with dual hydrogen flame detector. The column was 2 m. by 0.32 cm. and consisted of 15% diethylene glycol succinate on silanized Chromosorb W, 60/80 mesh. Column temperature was constant at 180°C. The relative amounts of each individual fatty acid were determined by comparison of the areas under the peaks drawn by the recorder and measured by a printing integrator (Perkin-Elmer Model 194B). The data were compiled and presented in table form. Comparisons were then made between each product and within each product for the six month course of the survey.

RESULTS

Complete analyses of total solids, fat, and fatty acid composition of all the products analyzed over the six-month period are given in Tables 4-15. Total solids and fat are expressed as a percentage on a weight basis while fatty acids are given in weight percentages of the total component fatty acids. Total saturates and unsaturates are expressed as a sum of the percentages of the representative fatty acid constituents. The results presented are based only upon the samples collected on the specified dates.

The percent total solids composition of the filled milk product A varied from 11.90 to 12.72 (Table 4). Fat ranged from 3.11 to 3.55 percent of the product. Laurate was the most prevalent fatty acid in all samples analyzed with a range of 47.27 to 85.88 percent of the total. Myristate was the second most prevalent followed by palmitate. Product A contained an extremely high amount of saturated fatty acids varying from 93.73 to 99.45 percent of the total during the six month period.

Filled milk beverage B (Table 5) possessed a fairly consistent total solids composition of about 12.7 percent for all months except the fifth where a high of 13.17 was

TABLE 4

COMPOSITION OF FILLED MILK A

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.55	12.72	12.51	12.37	12.24	11.90
Fat (%)	3.55	3.42	3.36	3.11	3.51	3.45
Fatty Acids[a]						
Caprylic (8:0)	7.24	7.31	9.88	5.65	3.04	6.32
Capric (10:0)	5.08	5.38	7.41	3.60	1.78	4.92
Caprioleic (10:1)						
Lauric (12:0)	47.27	55.14	52.47	67.92	85.88	54.05
Lauroleic (12:1)						
Myristic (14:0)	16.02	16.90	15.84	9.10	6.22	13.35
Myristoleic (14:1)						
Palmitic (16:0)	10.18	7.93	8.23	5.31	1.53	7.84
Palmitoleic (16:1)						
Stearic (18:0)	9.39	4.70	4.11	5.84	1.00	7.24
Oleic (18:1)	4.82	2.64	2.06	2.43	0.49	6.00
Linoleic (18:2)				0.15	0.06	0.27
Linolenic (18:3)						
Total Saturates (%)	95.18	97.36	97.94	97.42	99.45	93.73
Total Unsaturates (%)	4.82	2.64	2.06	2.58	0.55	6.27

[a] Expressed as a weight percentage of the component fatty acids

TABLE 5

COMPOSITION OF FILLED MILK B

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.74	12.72	12.52	12.67	13.17	12.79
Fat (%)	3.67	3.66	3.62	3.02	3.65	3.44
Fatty Acids[a]						
Caprylic (8:0)			0.02	0.32	0.03	0.09
Capric (10:0)	0.15	0.13	0.05	0.32	0.05	0.05
Caprioleic (10:1)				0.10		
Lauric (12:0)	0.18	0.66	0.29	0.69	0.17	0.60
Lauroleic (12:1)						
Myristic (14:0)	0.61	1.08	0.44	1.80	2.73	0.76
Myristoleic (14:1)					0.34	
Palmitic (16:0)	15.33	16.73	15.08	19.65	10.30	5.46
Palmitoleic (16:1)				0.23		
Stearic (18:0)	8.04	7.90	6.92	7.03	4.65	10.69
Oleic (18:1)	52.50	51.30	54.07	51.32	58.70	56.96
Linoleic (18:2)	21.86	22.20	21.47	17.72	22.17	24.47
Linolenic (18:3)	1.33		1.66	0.82	0.86	0.92
Total Saturates (%)	24.31	26.50	22.80	29.86	18.79	17.65
Total Unsaturates (%)	75.69	73.50	77.20	70.14	81.21	82.35

[a] Expressed as a weight percentage of the component fatty acids

TABLE 6

COMPOSITION OF FILLED MILK C

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.89	12.93	12.45	12.80	12.93	12.97
Fat (%)	3.19	3.33	3.03	3.12	3.48	3.21
Fatty Acids[a]						
Caprylic (8:0)	4.95	4.03	2.83	3.36	1.77	4.01
Capric (10:0)	3.30	2.75	2.47	2.88	1.21	3.27
Caprioleic (10:1)					0.28	
Lauric (12:0)	33.10	36.21	46.31	32.98	61.27	37.17
Lauroleic (12:1)					0.38	
Myristic (14:0)	9.95	9.02	6.25	8.31	4.67	9.01
Myristoleic (14:1)						
Palmitic (16:0)	11.12	9.59	8.98	11.50	6.34	10.75
Palmitoleic (16:1)				0.32		
Stearic (18:0)	9.73	6.67	6.58	7.35	3.87	8.37
Oleic (18:1)	26.66	30.91	26.05	32.27	19.58	26.43
Linoleic (18:2)	1.19	0.82	0.53	1.03	0.63	0.99
Linolenic (18:3)						
Total Saturates (%)	72.15	68.27	73.42	66.38	79.13	72.58
Total Unsaturates (%)	27.85	31.73	26.58	33.62	20.87	27.42

[a] Expressed as a weight percentage of the component fatty acids

TABLE 7

COMPOSITION OF FILLED MILK D

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.00	11.42	12.67	11.32	11.96	11.78
Fat (%)	3.35	3.31	3.38	3.30	3.56	3.16
Fatty Acids[a]						
Caprylic (8:0)	7.78	5.63	0.06	0.20	0.07	
Capric (10:0)	5.81	6.08	0.12	0.13	0.14	0.18
Caprioleic (10:1)						
Lauric (12:0)	61.78	63.83	0.23	1.26	0.34	0.28
Lauroleic (12:1)						
Myristic (14:0)	17.43	12.58	0.24	0.33	0.20	0.65
Myristoleic (14:1)						
Palmitic (16:0)	3.04	5.57	11.45	10.19	5.81	30.03
Palmitoleic (16:1)						
Stearic (18:0)	1.83	5.90	8.07	7.81	5.03	23.95
Oleic (18:1)	2.33	0.41	79.83	79.62	87.91	41.72
Linoleic (18:2)				0.46	0.50	2.76
Linolenic (18:3)						0.43
Total Saturates (%)	97.67	99.59	20.17	19.92	11.59	55.09
Total Unsaturates (%)	2.33	0.41	79.83	80.08	88.41	44.91

[a] Expressed as a weight percentage of the component fatty acids

TABLE 8

COMPOSITION OF FILLED MILK E

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.22	11.84	11.79	11.22	12.07	12.06
Fat (%)	3.58	3.54	3.64	3.29	3.41	3.56
Fatty Acids[a]						
Caprylic (8:0)	0.07	6.86	3.85	4.77	2.73	5.78
Capric (10:0)	0.18	4.49	2.22	2.99	1.95	4.50
Caprioleic (10:1)						
Lauric (12:0)		64.14	71.76	70.73	84.92	67.06
Lauroleic (12:1)						
Myristic (14:0)		13.66	9.13	7.93	6.25	8.83
Myristoleic (14:1)						
Palmitic (16:0)	11.02	5.24	4.57	4.45	1.90	4.61
Palmitoleic (16:1)						
Stearic (18:0)	6.13	4.61	4.08	4.03	1.76	4.29
Oleic (18:1)	80.33	1.00	4.32	5.09	0.49	4.76
Linoleic (18:2)	2.27		0.07	0.01		0.17
Linolenic (18:3)						
Total Saturates (%)	17.40	99.00	95.61	94.90	99.51	95.07
Total Unsaturates (%)	82.60	1.00	4.39	5.10	0.49	4.93

[a] Expressed as a weight percentage of the component fatty acids

TABLE 9

COMPOSITION OF FILLED MILK F

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.49	11.48	11.62	11.35	10.84	10.73
Fat (%)	3.33	3.51	3.54	3.36	3.42	3.57
Fatty Acids[a]						
Caprylic (8:0)	0.15	5.65	3.91	6.07	2.69	6.07
Capric (10:0)	0.28	4.38	2.66	4.31	1.81	4.33
Caprioleic (10:1)						
Lauric (12:0)		62.22	75.74	67.10	82.05	64.52
Lauroleic (12:1)						
Myristic (14:0)		17.11	10.38	11.42	6.79	10.86
Myristoleic (14:1)						
Palmitic (16:0)	10.37	3.71	3.34	5.61	2.47	5.25
Palmitoleic (16:1)				0.01		
Stearic (18:0)	6.83	5.82	3.53	2.92	2.17	4.36
Oleic (18:1)	82.37	1.11	0.44	2.43	1.96	4.12
Linoleic (18:2)				0.13	0.06	0.49
Linolenic (18:3)						
Total Saturates (%)	17.63	98.89	99.56	97.43	97.98	95.39
Total Unsaturates (%)	82.37	1.11	0.44	2.57	2.02	4.61

[a] Expressed as a weight percentage of the component fatty acids

TABLE 10

COMPOSITION OF FILLED MILK G

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.99	13.32	12.84	12.87	12.72	12.81
Fat (%)	3.26	3.19	3.34	3.60	3.28	3.21
Fatty Acids[a]						
Caprylic (8:0)	5.08	5.71	3.60	4.79	4.31	4.63
Capric (10:0)	3.45	4.44	2.95	2.77	2.74	3.85
Caprioleic (10:1)						
Lauric (12:0)	61.64	58.19	64.83	73.35	84.40	71.56
Lauroleic (12:1)						
Myristic (14:0)	19.14	15.15	10.92	8.41	5.19	9.32
Myristoleic (14:1)						
Palmitic (16:0)	4.96	7.88	8.61	4.04	1.67	4.52
Palmitoleic (16:1)				0.03		
Stearic (18:0)	3.55	5.49	6.09	4.49	1.12	3.93
Oleic (18:1)	2.18	3.14	2.97	2.09	0.57	2.15
Linoleic (18:2)			0.03	0.03		0.04
Linolenic (18:3)						
Total Saturates (%)	97.82	96.86	97.00	97.88	99.43	97.81
Total Unsaturates (%)	2.18	3.14	3.00	2.12	0.57	2.19

[a] Expressed as a weight percentage of the component fatty acids

TABLE 11

COMPOSITION OF FILLED MILK H

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	12.55	12.38	11.83	12.61	12.09	11.97
Fat (%)	3.27	3.46	3.58	3.24	3.20	3.23
Fatty Acids[a]						
Caprylic (8:0)			0.10	0.28	4.75	1.98
Capric (10:0)		0.04	0.14	0.19	3.66	1.92
Caprioleic (10:1)						
Lauric (12:0)	0.20	0.33	0.19	1.88	66.48	15.02
Lauroleic (12:1)				1.22		
Myristic (14:0)	0.28	0.21	0.28	0.75	11.52	4.64
Myristoleic (14:1)						
Palmitic (16:0)	14.53	12.82	15.99	13.44	5.54	11.78
Palmitoleic (16:1)						
Stearic (18:0)	6.54	6.36	8.00	7.71	4.03	7.69
Oleic (18:1)	56.01	56.97	51.23	52.40	3.51	40.16
Linoleic (18:2)	22.44	22.50	22.79	21.48	0.43	16.24
Linolenic (18:3)		0.77	1.28	0.65	0.08	0.57
Total Saturates (%)	21.55	19.70	24.70	24.25	95.98	43.03
Total Unsaturates (%)	78.45	80.30	75.30	75.75	4.02	56.97

[a] Expressed as a weight percentage of the component fatty acids

TABLE 12

COMPOSITION OF LIQUID COFFEE-WHITENER 1

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	20.04	19.74	19.86	20.24	20.47	19.28
Fat (%)	11.44	10.91	12.88	11.45	11.24	11.35
Fatty Acids[a]						
Caprylic (8:0)			0.09	0.13	0.05	0.05
Capric (10:0)		0.05	0.12	0.65	0.06	0.12
Caprioleic (10:1)						
Lauric (12:0)	0.09	0.23	0.64	2.75	0.43	0.35
Lauroleic (12:1)				0.45	0.07	
Myristic (14:0)	0.02	0.13	0.29	0.49	0.06	0.28
Myristoleic (14:1)						
Palmitic (16:0)	10.12	10.75	10.08	7.44	6.91	5.67
Palmitoleic (16:1)						
Stearic (18:0)	9.77	11.48	9.94	9.86	7.66	11.25
Oleic (18:1)	79.76	77.21	78.12	78.17	84.60	82.05
Linoleic (18:2)	0.24	0.14	0.72	0.06	0.16	0.23
Linolenic (18:3)		0.01				
Total Saturates (%)	20.00	22.43	21.07	21.32	15.17	17.72
Total Unsaturates (%)	80.00	77.57	78.93	78.68	84.83	82.28

[a] Expressed as a weight percentage of the component fatty acids

TABLE 13

COMPOSITION OF LIQUID COFFEE-WHITENER 2

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	19.46	19.05	19.03	18.02	19.65	18.43
Fat (%)	9.49	9.57	8.30	7.49	9.79	8.02
Fatty Acids[a]						
Caprylic (8:0)		6.35	3.51	3.16	3.32	3.61
Capric (10:0)		7.27	2.15	2.55	2.26	2.90
Caprioleic (10:1)						
Lauric (12:0)	0.19	48.88	74.38	68.77	83.54	74.10
Lauroleic (12:1)				0.24		
Myristic (14:0)	0.11	17.10	10.06	8.72	6.67	8.29
Myristoleic (14:1)						
Palmitic (16:0)	14.13	8.71	3.92	4.33	2.09	4.40
Palmitoleic (16:1)						
Stearic (18:0)	11.53	10.88	4.96	4.92	1.53	4.48
Oleic (18:1)	73.96	0.76	1.00	7.00	0.57	2.15
Linoleic (18:2)	0.08	0.05	0.02	0.31	0.02	0.07
Linolenic (18:3)						
Total Saturates (%)	25.96	99.19	98.98	92.45	99.41	97.78
Total Unsaturates (%)	74.04	0.81	1.02	7.55	0.59	2.22

[a] Expressed as a weight percentage of the component fatty acids

TABLE 14

COMPOSITION OF LIQUID COFFEE-WHITENER 3

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	19.14	19.79	21.24	19.13	20.31	17.75
Fat (%)	7.10	7.43	8.96	7.66	8.23	7.69
Fatty Acids[a]						
Caprylic (8:0)	8.78	7.59	3.95	3.06	3.69	3.81
Capric (10:0)	5.51	4.65	2.36	2.58	2.20	2.82
Caprioleic (10:1)						
Lauric (12:0)	60.95	55.86	78.29	77.72	78.58	76.44
Lauroleic (12:1)						
Myristic (14:0)	14.71	16.95	8.58	8.95	11.36	8.73
Myristoleic (14:1)						
Palmitic (16:0)	5.18	7.64	2.99	3.24	1.86	3.41
Palmitoleic (16:1)						
Stearic (18:0)	4.01	6.44	2.83	2.98	1.85	1.38
Oleic (18:1)	0.86	0.87	1.00	1.44	0.43	
Linoleic (18:2)				0.03		
Linolenic (18:3)						
Total Saturates (%)	99.14	99.13	99.00	98.53	99.57	100.00
Total Unsaturates (%)	0.86	0.87	1.00	1.47	0.43	0.00

[a] Expressed as a weight percentage of the component fatty acids

TABLE 15

COMPOSITION OF LIQUID COFFEE-WHITENER 4

	Month					
	June	July	August	September	October	November
Total						
Solids (%)	18.35	17.86	18.27	17.20	18.67	18.94
Fat (%)	11.02	11.50	9.87	8.80	11.75	11.74
Fatty Acids[a]						
Caprylic (8:0)	2.50	2.60	1.04	1.77	1.20	2.52
Capric (10:0)	2.00	2.41	1.23	1.28	1.08	2.25
Caprioleic (10:1)						
Lauric (12:0)	65.34	59.65	80.07	79.81	83.00	77.34
Lauroleic (12:1)						
Myristic (14:0)	12.71	13.10	6.62	6.74	5.92	7.22
Myristoleic (14:1)						
Palmitic (16:0)	5.16	6.75	2.90	3.46	2.59	3.45
Palmitoleic (16:1)						
Stearic (18:0)	12.05	15.24	7.82	6.75	5.85	6.51
Oleic (18:1)	0.24	0.25	0.32	0.17	0.33	0.71
Linoleic (18:2)				0.02	0.03	
Linolenic (18:3)						
Total Saturates (%)	99.76	99.75	99.68	99.81	99.64	99.29
Total Unsaturates (%)	0.24	0.25	0.32	0.19	0.36	0.71

[a] Expressed as a weight percentage of the component fatty acids

recorded. Fat was also somewhat consistent except for the fourth month when it reached a low of 3.02 percent. Unlike product A, oleiate was the predominate fatty acid in product B with a range of 51.30 to 58.70 percent of the total. Linoleiate and palmitate were present in the next highest concentrations. Product B contained much higher levels of unsaturated fatty acids than did product A, with a range of 70.14 to 82.35 percent.

The total solids content of filled milk C was one of the highest of all the filled milk products tested averaging approximately 12.83 percent for the entire test period (Table 6). Product C's fat content was among the lowest of all the products tested with a range of 3.03 to 3.48 percent. Laurate and oleiate together comprised about two-thirds of the total fatty acids throughout the test period. Palmitate, myristate, and stearate were the other significant acids appearing in this product. The fatty acid content of product C was unique among the filled milk products tested, in that, there was a ratio of about 3:1 between total saturated fatty acids and unsaturated fatty acids. In all other products tested, the ratio of saturates to unsaturates approached either 9:1 or 1:4 with the exception of the sixth sample of product H, which approximated a 1:1 ratio (Table 11). Product C's total saturated fatty acid content varied from 66.38 to 79.13 percent. Thus, a significant level of unsaturated fatty acids was also present.

Total solids content of filled milk product D ranged from 11.32 to 12.67 percent (Table 7). Fat percentage varied from 3.16 to 3.56. For the first two months laurate (61.78 and 63.83%) and myristate (12.58 and 17.43%) were the primary fatty acid constituents. There was consequently a very high total saturated fatty acid content for each of these two months (97.67 and 99.59%). Oleiate was, however, the primary fatty acid from the third to the fifth month with a range of 79.62 to 87.91 percent. Palmitate and stearate were also present in significant amounts. During this period the unsaturated fatty acids were predominate, ranging from 79.83 to 88.41 percent. Another significant change in fatty acid composition took place during the sixth month. Even though greatly reduced in concentration, oleiate still remained the primary fatty acid at 41.72 percent of the total. Palmitate increased to 30.03 percent with stearate increasing to 23.95 percent. Total saturate fatty acid content then increased to 55.09 percent and total unsaturated dropped to 44.91 percent. This gave product D a fatty acid composition, in terms of saturates and unsaturates, somewhat resembling that of fluid whole milk.

Filled milk beverages E and F are presented together because of their nearly identical fatty acid content during the entire sampling period. The percent total solids content however ranged from 10.73 to 12.49 with near identical variations occurring within each product for four out of the six months (Tables 8 and 9). During the last two months product F contained approximately 10 percent less total solids than did product E. For any particular month the total fat levels of the two products were nearly identical. There was however a between month variation detected which ranged from 3.29 to 3.64 percent. While there was also a month to month variation in the component fatty acid composition of the two products there was little variation between the two products. Oleiate was the primary fatty acid the first month accounting for slightly over 80 percent of the total. The products contained about 82 percent total unsaturated fatty acids. However, after the first month there was a change in the fatty acid composition of the two products resulting in a resemblance to product A. Laurate became the most prevalent acid during the final five months with a range of 62.22 to 84.92 percent. Total saturated fatty acids showed a marked reversal ranging from 94.90 to 99.56 percent of the total.

The total solids content of filled milk G was consistently among the highest of all the products tested with a range of 12.72 to 13.32 percent (Table 10). The fat composition was almost always among the lowest varying from 3.19 to 3.60 percent. Product G was similar to product C in regards to its high total solids and low total fat content. The fatty acid composition of product G was fairly consistent throughout the six month period with laurate (58.19 to 84.40%) predominating and myristate (5.19 to 19.14%) being the next most prevalent. Product G resembled products A, E, and F in fatty acid composition. Total saturated fatty acid content was quite consistent with a range of 96.86 to 99.43 percent of the total.

In the case of filled milk beverage H, the total solids content varied from 11.83 to 12.61 percent and fat ranged from 3.20 to 3.58 percent (Table 11). For the first four months the fatty acid composition of the product remained fairly constant with palmitate, oleiate and linoleiate being the primary fatty acids. Oleiate was the principle fatty acid with a range of 51.23 to 56.97 percent while linoleiate was the second most prevalent accounting for 21.48 to 22.79 percent of the total. The total unsaturated fatty acids varied from 75.30 to 80.30 percent. During the fifth month laurate became the predominate fatty acid, accounting for 66.48 percent of the total, changing the fatty acid composition drastically. The total saturated fatty acids were increased to 95.98 percent. A major change again took place during the final month in the fatty acid composition of product H. Oleiate became the most prevalent acid, accounting for 40.16 percent of the total. Linoleiate, laurate and palmitate were also present in significant amounts. Unsaturated fatty acids consequently composed 56.97 percent of the total.

Among the coffee-whiteners, product 1 had a range in total solids of 19.28 to 20.47 percent during the six month test period (Table 12). Percent fat varied from 10.91 to 12.88. The fatty acid composition remained quite constant throughout the entire six month period. Oleiate was the primary fatty acid with a range of 77.21 to 84.60 percent of the total. Unsaturated fatty acids accounted for 77.57 to 84.83 percent of the total acids present.

The total solids in coffee-whitener sample 2 ranged from 18.02 to 19.65 percent while fat varied from 7.49 to 9.79 percent (Table 13). During the first month, oleiate was the major fatty acid comprising 73.96 percent of the total. Unsaturated fatty acids predominated saturates about 3:1. Following the first month a major change in fatty acid composition took place. Laurate became the most prevalent fatty acid for the final five months of the test period, varying from 48.88 to 83.54 percent of the total. Saturated fatty acids ranged from 92.45 to 99.41 percent of the total acids.

Coffee-whitener product 4 had a total solids content varying from 17.20 to 18.94 percent while percent fat ranged from 8.80 to 11.75 (Table 15). The fatty acid composition of product 4 resembled that of product 3. Laurate, ranging from 59.65 to 80.07 percent, was again the most prevalent and myristate, stearate and palmitate were also present in significant amounts. Total saturated fatty acids were consistently the highest of any product tested varying from 99.29 to 99.81 percent of the total.

DISCUSSION

The results of this study have shown that significant compositional variations occurred in filled milk and liquid coffee-whiteners, not only between products from various manufacturers but also within products marketed by a given manufacturer, during the six month test period. Of the eight filled milk products studied, five showed variations of greater than 10% of their minimum and maximum fat content (Tables 4 to 11). Three of the four liquid coffee-whiteners had ranges greater than 15% (Tables 12 to 15). The variation in total solids content of both the filled milks and also coffee-whiteners was not as distinct. Five of the eight filled milks and all four of the liquid coffee-whiteners showed variation of less than 8%. In fact, most of the variations found in the total solids content was accounted for by fat content variations.

These variations in fat and total solids content seem to indicate a lack of adequate attention to composition control in many cases in the various operations involved with producing the product. The variations in fat content could be attributed to several causes. Some of the possibilities are: (1) a trend to lower fat content for cost-price advantage, (2) perfunctory addition of the fat to the product, and (3) since standards of identity have not been adopted, the manufacturer does not have to adhere to a regulatory system but rather bases product composition control on management decisions.

There could also be several reasons for the somewhat consistent level of the total solids in the products tested. One possibility is that the solids-not-fat component of these products might serve as a base in other nonfat products. Thus, the processors could formulate one standard solids-not-fat base and use it in a variety of products. Consequently, if the solids-not-fat content remained fairly consistent then the primary variation in the total solids content would result from variations in the fat content.

Some indication of the source of fat used in both the filled milks and liquid coffee-whiteners can be obtained from an examination of the constituent fatty acids of the fat. Laurate was the most predominate fatty acid in products A, E, F, G, 2, 3, and 4. Myristate, palmitate, and stearate were also present in significant amounts. Coconut oil is the only known naturally occurring fat which bears any resemblance to this type of fatty acid distribution (Table 2). These products, as well as coconut oil, all have a saturated fat content of over 90 percent. On the basis of this type of fatty acid distribution there is strong indication that the fat in these products is at least primarily, if not entirely, coconut oil. Therefore, due to a fatty acid distribution similar to coconut oil, the previously discussed nutritional implications attributed to coconut oil (1, 2, 5, 19, 20, 21, 27, 29, 44, 45, 47, 52) may also be attributed to products A, E, F, G, 2, 3, and 4. Thus, the consumption of any of these products in large significant amounts may result in higher blood cholesterol levels, low growth promoting properties, essential fatty acid deficiencies, and depressed calcium absorption. The more dramatic effects seem to occur most often in infants and children.

Oleiate was the major fatty acid in products B, D, H, and 1. Palmitate, stearate, and linoleiate were also present in significant amounts. While there are naturally occurring vegetable oils, specifically peanut and olive oil, possessing a similar fatty acid composition to that in products B, D, H, and 1 (Table 2), economic considerations (13) may be assumed to preclude their use in these filled milk or coffee-whitener products.

If, however, more economical naturally occurring vegetable oils, such as corn, soybean or cottonseed oil, were subjected to a partial hydrogenation process they could conceivably have a fatty acid distribution very similar to that of products B, D, H, and 1. Partial hydrogenation occurs during processing of the various oils from the natural state to a more refined state (40). This process is used quite extensively in the margarine and shortening industries (40).

There are indications, other than economical, which imply that the fat in products B, D, H, and 1 was not the naturally occurring olive or peanut oils. Linoleiate occurs in greater amounts in these products than in olive oil, thus, apparently eliminating olive oil in its natural state. Also, greater amounts of stearate are present in products B, D, H, and 1 than in peanut oil. The most plausible choice, therefore, indicates that the partial hydrogenation of the more economical oils was the fat source for products B, D, H, and 1. The nutritional implications attributed to partially hydrogenated vegetable oils (8, 12, 30, 32, 33, 39, 42) could conceivably occur should large significant amount of products B, D, H, and 1 be consumed. Thus, certain biological abnormalities might occur due to the ingestion of the biologically less desirable, partially hydrogenated fats.

The presence of high amounts of oleiate, linoleiate and linolenate, as occurs in products B, D, H, and 1 indicates a highly unsaturated fat. Previously discussed evidence (18, 22, 24, 25, 44) showed that high amounts of unsaturated fatty acid intake may result in prolonged clotting time of blood, decreased Vitamin E supply for infants, formation of harmful peroxides, accentuation of the aging process and production of high cholesterol and fat in the liver.

Although the fat of products B, D, H, and 1 was highly unsaturated, a partial hydrogenation may have converted the polyunsaturated fatty acids of the natural fat to their more saturated forms. Consequently, it is questionable whether the processed fat could be defined as strictly "high in polyunsaturates". This misnomer is used frequently in describing product composition.

Product C contained a fatty acid composition somewhat in between coconut oil and the partially hydrogenated oils. It was not characteristic of either. The ratio of unsaturated to saturated fatty acids was also in between that characteristic of the two types of oils. The fat therefore may have been a mixture of both coconut oil and a partially hydrogenated vegetable oil or oils.

Finally, there are significant similarities between certain filled milks and coffee-whiteners. The filled milk product A, is produced by the same processor as the coffee-whitener product 4; as are products E and F produced by the same processor as product 2; and also product G the same processor as product 3. The results of this study show the fatty acid composition of the filled milk products to resemble very closely the composition of the coffee-whiteners produced by the same processor. Thus, it may be assumed that the fat used by the processor in one product is identical to that used in the other.

As mentioned previously, the sales in Arizona of the filled milk products has reached a sizable proportion of the total Class I fluid milk sales. However, filled milk sales have consistently decreased for the last twelve months (Table 2). There are perhaps a multitude of factors for the decrease in sales. One factor may be the extensive promotional campaign by groups affiliated with the dairy industry to inform the consumer about the composition of filled milk products as compared to fluid whole milk.

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