Fat Characteristics and Stability of Nondairy and Dairy Powdered Creamers

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Four representative nondairy powdered creamers and two cow's milk powdered creamers were analyzed for fat and fatty components and changes induced before and after ambient room temperature incubation. They were analyzed for melting point, refractive index, unsaponifiable matter, and peroxide value. The sterols in nondairy powdered creamers were mainly plant, campesterol, stigmasterol and β-sitosterol and their fatty acids were very highly saturated, 95.0 to 97.8%. Incubation of powders for 3 months at ambient room temperature developed astringent and oxidized flavor and an increase in oxidized fatty acids and peroxide values but not in acid number. In cow's milk powdered creamers, sterols were cholesterol and related, and their fatty acids were partly saturated with a few branched chains developing during storage. Incubation for 3 months at ambient room temperature developed slight astringent flavor and an increase in oxidized fatty acids, acid number, and peroxide values.

Powdered nondairy creamers exist as milk and cream replacers for whitening coffee and for other traditional milk uses. Recent studies, Filsoof *et al.* (1973) and Kosikowski (1971), on the characteristics of nondairy imitation milks excluded nondairy creamers, but the need for information on these products is evident. The present report is concerned with the nature of fat and the changes that may occur with time in nondairy powdered creamers.

MATERIALS AND METHODS

Nondairy powdered creamers representing four major brands with active turnover were obtained in 171–453-g sealed glass containers from two local supermarkets. Ingredients listed included in all of these powders were: corn syrup solids, vegetable fat, sodium caseinate, dipotassium phosphate, emulsifier, sodium silico-aluminate, artificial flavor and colors, except one where β-carotene and riboflavin were also added. No cow's milk or dairy powdered creamers were available domestically so such creamers produced commercially in Japan from cow's milk were obtained. One case lot of fresh dairy powder creamer packaged under nitrogen was air freighted to the University and stored at 5° for 15 months before testing; another fresh case lot from the same Japanese source was obtained a year later at the same time as the nondairy powdered creamers.

For stability testing, containers of the powdered creamers were separated into three groups upon receipt. The first group was held sealed at 5° until analyzed. A second group of chilled powders was stored at ambient room temperature for 3 months with package seal intact, and a third group of chilled powders was stored for 3 months with package seal broken and capped loosely. The contents were totally transferred to a clean beaker and mixed. Enough samples were removed for taste and fat concentration measurement (50 g), and from the remaining amount fat was extracted and analyzed.

Fat Extraction and Analysis. Fat extraction and analytical procedures for fats and fatty components were those used by Filsoof *et al.* (1973) for nondairy imitation milks. Fat was extracted from powders using Corning extra large size Soxhlet extractors with ethyl ether. Recovery of 26 g of fat was required for the tests in duplicate, obtained by extracting up to 4–150-g lots of powder for 4–5 hr. Following fat extraction, the solvents were evaporated gently in an oven at 55° under nitrogen to prevent deterioration and the fat was filtered through Whatman no. 2 paper and stored under nitrogen at 4°.

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Unsaponifiable Matter and Sterols. Unsaponifiable matter values were obtained as described in the Official Methods of the American Oil Chemists' Society (AOCS) (1967). Thin-layer chromatography, as outlined in Official Methods of the Association of Analytical Chemists (AOAC) (1970), separated sterols from unsaponifiable matter. The latter was dissolved in chloroform and transferred on a thin-layer sheet, Eastman chromogen, 6060 silica gel with fluorescent indicator, which was placed in a developing chamber. Sterol identification was achieved by gas chromatography on a Varian Aerograph model 2700 flame ionizer coupled with a Westronic Recorder, Model LD 11A. The column used was 0.32 × 152 cm, packed with 3% SE-30, 100–120 Varaport under conditions used by Filsoof *et al.* (1973). The relative sterol percentage of total sterols was calculated from the peak surface areas and specific measurements of cholesterol and related sterols were obtained by dividing the surface area of the peaks by the surface area calculated for 1 mg of injected sterol from a standard mixture.

Fatty Acid Composition and Oxidized Fatty Acids. Fatty acids in a free state were obtained from the soap solution as described in Official Methods (AOAC) (1970) and separated as nonoxidized or oxidized according to their solubility in petroleum ether. Nonoxidized fatty acids were methylated using the AOCS method (1967) and separated by glc in a 0.32 × 244 cm stainless steel column packed with 20% diethylene glycol succinate 60–80 mesh on Chromosorb W A/W under conditions described by Filsoof *et al.* (1973).

Other Fat Tests. Tests on the extracted fat included melting point by capillary tube, refractive index by Abbe refractometer, and peroxide values according to AOCS methods (1967), acid number by the AOAC procedure (1970), and fat concentration by the method of Mojonnier (1925).

Flavor was scored by a three-person panel using as a guide the American Dairy Science Association milk scorecard on 12% T.S. reconstituted samples in water according to Downs *et al.* (1954).

RESULTS

Fat and Fat Constants. Fat in the nondairy powdered creamers was 34.16 to 37.53% and averaged 36.27%; that in the two cow's milk powdered creamers was 29.08 and 29.18% (Table I).

The melting points of nondairy imitation milk powders were 36.4 to 50.0°, with two fats showing extreme hardness, and those of the cow's milk creamers were 36.6 and 38.0°. Refractive indices of the nondairy powdered creamers' fats varied from 1.4475 to 1.4495 and for cow's milk fats, 1.4541 to 1.4559 (Table I). Unsaponifiable matter in

Table I. Concentration of Fat and Fat Constants in Nondairy Imitation Creamer Powders

Product[a]	Fat, %	Melting point,[b] °C	Refractive index at 40°	Unsaponifiable matter, %
1	36.15	36.4	1.4488	0.45
2	37.53	49.6	1.4491	0.49
3	34.16	39.5	1.4475	0.46
4	37.26	50.0	1.4495	0.34
5(c)	29.18	36.6	1.4541	0.41
6(c)	29.09	38.0	1.4559	0.48

[a] 1–4 held sealed 1 month at 5° before analysis. 5(c), cow's milk creamer powder control obtained from Japan in 1972 held sealed 3 months at 5° before analysis. 6(c), cow's milk creamer powder control obtained from Japan in 1971 held sealed 15 months at 5° before analysis. [b] Temperature at which initial softening of the fat is observed.

Table II. Type and Relative Proportion of Sterols in Nondairy Imitation Milk Creamer Powders

Product[a]	Sterols				
	Cholesterol and related sterols	Campesterol	Stigmasterol	β-Sitosterol	Others
	% of total sterols				
1	ND[b]	13.80	44.02	42.00	ND
2	6.17	6.27	10.16	77.40	ND
3	7.59	7.90	4.28	80.24	ND
4	12.95	6.55	11.37	69.15	ND
5(c)	100	ND	ND	ND	ND
6(c)	100	ND	ND	ND	ND

[a] 1–4 held sealed 1 month at 5° before analysis. 5(c), cow's milk creamer powder control obtained from Japan in 1972 held sealed 3 months at 5° before analysis. 6(c), cow's milk creamer powder control obtained from Japan in 1971 held sealed 15 months at 5° before analysis. [b] ND, not detectable.

fats of nondairy powdered creamers ranged from 0.34 to 0.49% and in cow's whole milk from 0.41 to 0.48%.

Sterols. Sterols in powdered creamers not stored at ambient room temperature are shown from their peak appearance as percent of total sterols (Table II).

The nondairy powdered creamers mainly displayed plant sterols such as campesterol, stigmasterol, and sitosterol, with the latter contributing 42.00–80.24% to total sterols (Table II). Campesterol ranged from 6.55 to 13.80% and stigmasterol from 4.28 to 44.02%. Three nondairy creamers showed small relative percentages of sterols, 6.17 to 12.95%, associated closely with the cholesterol and related sterol peaks.

In the cow's milk powdered creamers, only animal sterols, presumably cholesterol, dihydro-, and 7-dehydrocholesterol, were observed at 267.8 and 247.8 mg/100 g of fat.

Fatty Acids. In the unincubated powders, group 1, 96.62% of the fatty acids of the nondairy powdered creamers was saturated, while only 69.54% of the fatty acids of the cow's milk powdered creamers was saturated (Table III). The fatty acids appearing in largest relative amounts in the nondairy creamers were C_{12}, C_{14}, C_{18}, and C_{16}, indicating the presence of coconut fat or fat resembling coconut.

The incubated nondairy powdered creamers held with the seal broken for 3 months at room temperature, group 3, showed an increase in C_{12} fatty acids and a decrease in C_{18}-1. A cow's milk powdered creamer, 5(c) held under the same storage condition, had its lower saturated fatty acids up to and including C_{12} increase significantly and

Table III. Fatty Acids of Nondairy Imitation Creamer Powders

Product	Fatty acid carbon chain																
	$<C_6$	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$>C_{18}$
							Chilled powders,[a] % of total fatty acids											
1	t[d]	0.27	t	3.93	t	3.45	t	36.35	t	14.38	t	15.22	0.06	24.13	1.90	0.08	0.23	NC[c]
2	0.03	0.38	t	7.43	t	6.32	t	41.16	t	20.98	t	9.09	0.18	11.92	2.52	t	t	ND
3	t	0.27	t	6.84	t	6.11	t	38.67	t	18.78	t	9.60	t	15.86	3.87	t	t	ND
4	0.07	0.37	t	6.65	t	6.30	t	42.7	t	19.70	t	8.26	0.19	10.76	5.00	t	t	ND
5(c)	t	0.83	t	0.97	0.13	2.47	0.33	2.88	0.31	11.34	3.67	34.58	2.56	11.26	25.72	1.49	0.37	0.96
6(c)	0.10	1.26	t	1.02	t	2.31	0.37	2.96	0.44	9.71	4.02	24.16	6.11	14.10	28.46	1.61	1.97	1.64
							Incubated powders,[b] % of total fatty acids											
1	t	0.67	t	5.00	t	4.39	t	41.58	t	14.56	t	13.39	t	20.12	0.29	t	t	ND
2	t	0.14	t	6.25	t	5.08	t	51.44	t	15.64	t	8.26	t	12.77	0.42	t	t	ND
3	t	0.20	t	6.48	t	6.37	t	48.62	t	16.68	t	8.84	t	12.32	0.54	t	t	ND
4	0.02	0.24	t	7.14	t	6.17	t	45.31	t	17.30	t	11.18	0.08	12.36	0.20	t	t	ND
5(c)	0.20	1.53	t	1.34	t	2.68	0.24	4.30	0.34	11.93	2.27	32.96	1.62	10.13	28.92	1.48	0.06	ND
6(c)									Not run									

[a] Before analysis, powders 1–4 held 1 month at 5°; powder 5(c) held 3 months at 5°; powder 6(c) held 15 months at 5°. [b] Held 3 months at room temperature with package gas seal broken. [c] ND, not detectable. [d] t, trace.

Table IV. Oxidized Fatty Acids, Acid Number, and Peroxide Values of Fat in Incubated Nondairy Creamer Powders

Product	Oxidized fatty acids, %			Acid no., mg of KOH to neut. 1 g of fat			Peroxide value, mequiv of peroxide/kg		
	Non-incubated powders[a]	Incubated powders[b]		Non-incubated powders[a]	Incubated powders[b]		Non-incubated powders[a]	Incubated powders[b]	
		A	B		A	B		A	B
1	0.30	0.35	0.54	0.57	0.57	0.57	3.2	9.4	18.2
2	0.53	0.63	0.69	0.76	0.76	0.77	7.9	21.7	26.2
3	0.61	0.64	0.74	0.62	0.62	0.63	1.8	3.7	7.9
4	0.46	0.47	0.61	0.41	0.41	0.44	5.9	6.3	15.8
5(c)	0.05	0.16	0.23	0.24	0.65	0.65	1.2	17.5	29.4
6(c)	0.46	*c*	*c*	0.63	*c*	*c*	2.5	*c*	*c*

[a] Before analysis, powders 1–4 held 1 month at 5°; powder 5(c) held 3 months at 5°; powder 6(c) held 15 months at 5°. [b] Chilled powders incubated for 3 months at room temperature: A, package gas seal intact; B, package gas seal broken. [c] Not run.

Table V. Flavor Quality of Incubated Nondairy Creamer Powders

Product	Nonincubated powder[a]		Incubated powders 3 months at room temperature, gas seal intact		Incubated powders 3 months at room temperature, gas seal broken	
	Flavor score	Comment	Flavor score	Comment	Flavor score	Comment
1	39.0	Flat	38.5	Flat, slightly sweet	38.0	Flat, slightly sweet, beany
2	38.5	Flat	37.5	Flat, slightly astringent	36.0	Flat, slightly oxidized, astringent
3	38.0	Flat, cereal	38.0	Flat, lacks freshness	36.0	Flat, oxidized, lacks freshness
4	39.0	Flat	39.0	Flat, very slightly astringent	37.5	Creamy, astringent
5(c)	39.5	Excellent	39.5	Excellent	39.0	Very slightly astringent
6(c)	39.5	Excellent	*b*	*b*	*b*	*b*

[a] Before analysis, powders 1–4 held 1 month at 5°; powder 5(c) held 3 months at 5°; powder 6(c) held 15 months at 5°. [b] Not run.

C_{14} and C_{16} branched-chain fatty acids developed to 0.13 and 0.20% of total fatty acids. Also observed after incubation at room temperature were unsaturated C_{14} and C_{16} fatty acids (0.74 and 1.09% of total). Results of group 2 samples incubated sealed for 3 months at room temperature showed similar changes in fatty acids.

Oxidized Fatty Acids, Acid Number, and Peroxide Values. Fat analyses of the four freshly obtained nondairy powdered creamers showed the following additional characteristics: oxidized fatty acids, 0.30 to 0.46%; acid number, 0.41 to 0.76; and peroxide value, 1.8 to 7.9 (Table IV). The chilled cow's milk powdered creamer 5(c) displayed the following values: oxidized fatty acids, 0.05%; acid number, 0.24; and peroxide value, 1.17. A second cow's milk powdered creamer 6(c) held 15 months at 5° prior to testing had oxidized fatty acids 0.46%, acid number 0.63, and peroxide value 2.54.

Nondairy powdered creamers incubated sealed for 3 months at ambient room temperature showed little change in oxidized fatty acid values and acid number, but a marked increase in the peroxide value; similarly, nondairy powders incubated with the seal broken for 3 months at room temperature displayed no change in acid number but a definite increase in oxidized fatty acids and a very pronounced increase in peroxide values (Table IV). The cow's milk powdered creamer 5(c) held under the same time-temperature condition showed marked increases in all three constants in bottles sealed or with broken seal.

Flavor and Appearance. Freshly obtained nondairy powdered creamers reconstituted to 12% total solids generally gave flat flavors without much milk flavor character (Table V). After 3 months at room temperature, the flavors of three of the powdered creamers (no. 2, 3, 4), regardless of whether the package seal was intact or broken, acquired either a lack of freshness quality or an oxidized flavor or both. One nondairy powdered creamer, no. 1, was relatively stable to such flavor deterioration. The cow's milk powdered creamer 5(c) had excellent flavor after 3 months at room temperature with seal intact but acquired a very slight oxidized flavor held under the same conditions with seal broken. The second cow's milk powder creamer 6(c) still gave excellent flavor after 15 months at 5°.

Colors of the reconstituted nondairy powdered creamers were flat white and of the cow's milk powdered creamers were creamy white when fresh or stored.

DISCUSSION

Nondairy powdered creamers used as coffee whiteners and, in some instances, as milk replacements for prepared foods are reputed to be more stable to fat deterioration than their cow's milk counterparts. Compared with present counterparts from Japan, which were evidently subjected to ion-exchange treatments as deduced from their very low calcium and magnesium levels, stability differences were not great. The fat stability characteristics of both types of creamers held under conditions simulating, to some degree, warehouse and home storage, showed that the flavor score of the cow's milk powdered creamer was initially higher than those of nondairy powdered creamers and this score was maintained for the 3 months at room temperature in sealed containers, despite increases in oxidized fatty acids and peroxide number, indicating better keeping quality of dairy creamers over nondairy creamers. The flavor of creamers may not be considered important in competition with the predomi-

nating flavor of coffee but a strongly oxidized or astringent flavor conceivably could adversely influence otherwise good coffee or milk substituted foods.

Sterols in nondairy powdered creamers associated with the cholesterol or related sterol peaks may be attributed to the presence of activated ergosterol or to cholesterol contaminants from added casein or emulsifiers.

Filsoof *et al.* (1973) observed that the fatty acids of 14 nondairy imitation milks were predominately unsaturated. In these four nondairy powdered creamers, representing four major brands, the fatty acids were very highly saturated, 95.0 to 97.8%.

Creamers have not been considered seriously as a vehicle for supplying food nutrients, but coffee drinkers do acquire nutrients through the addition of fresh cream, milk, or creamers. Also, some manufacturers recommend that their powdered nondairy creamers can replace milk in some menu items. The nutritional aspect, therefore, merits some attention because the list of ingredients on the label does not fully indicate its composition. In the present study nondairy creamers contained highly saturated fats and mainly plant sterols and cow's milk powdered creamers contained partly saturated fat and animal sterols. Depending upon the amount of whitened coffee consumed, the choice of creamer affects the nutrient intake.

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Lipid Autoxidation in Precooked Dehydrated Sweet Potato Flakes Stored in Air

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Destruction of carotene and fatty acids during autoxidation of precooked dehydrated sweet potato flakes was studied in relation to oxygen uptake. Lipids of the oxidized flakes were separated into surface and bound components before analysis. Major fatty acids were identified and quantitated by gas chromatography. Carotene was determined spectrophotometrically. Results showed that surface carotene was lost about 100 times more rapidly than bound carotene. In addition it was observed that surface fatty acids were not destroyed nearly as rapidly as carotene but much faster than bound fatty acids. More oxygen was absorbed than could be accounted for by peroxide formation, indicating that other oxygen-consuming reactions are involved in flake autoxidation. The data confirmed an earlier observation that autoxidation of sweet potato flakes occurs *via* a dual reaction mechanism, with surface and bound lipids oxidizing concurrently but at very different rates.

Precooked dehydrated sweet potato flakes (flakes) undergo rapid oxidative deterioration unless stored in atmospheres of low oxygen content. The usual course of events in flake autoxidation is a fairly rapid loss of a part of the carotene and the simultaneous development of unpleasant off-flavors. Due to the ineffectiveness of antioxidants in controlling off-flavor development, Deobald and McLemore (1964) concluded that the only suitable alternative is packaging in a nitrogen atmosphere.

Subsequently Walter *et al.* (1972) proposed that solvent extraction of flakes to remove surface carotene and lipids should retard development of off-flavor. Their report suggested that autoxidation of flakes occurs in a bimodal fashion, with surface lipids being attacked at a faster rate than lipids which are bound. Removal of the surface lipids with a suitable solvent would thus leave only bound lipids which are oxidized at a much slower rate and would result in increased shelf life of flakes.

Sweet potato lipid, although present in small amounts (1.5–2.5%, dry basis), is highly unsaturated and thus would be expected to be very susceptible to oxidative attack. In addition to containing the unsaturated fatty acids, linoleic and linolenic, which comprise about 55% of the total fatty acids (Walter *et al.*, 1971), Centennial sweet potatoes contain a relatively large amount of carotenes, primarily β-carotene. Since carotene destruction in autoxidizing flakes is obvious and fairly easy to follow, this property has been used by several groups as a probe to evaluate the progress of the oxidation (Deobald *et al.*, 1964; Walter *et al.*, 1970). No information has been published concerning the fate of fats.

We undertook in our study to determine the manner in which fat autoxidation occurs during storage in air. Of special interest is the difference in the rate of oxidation for bound and surface lipids. The study reported here has attempted to relate oxygen uptake, carotene, and fat destruction data for surface and bound lipids.

MATERIALS AND METHODS

Samples. Precooked dehydrated sweet potato flakes were prepared from the 1971 crop as previously described (Purcell and Walter, 1968). This paper reports the results obtained from studying the oxidative deterioration of two separate batches of flakes: S-1, Centennial roots from a root maintenance collection harvested October 1971 and processed immediately after being cured, moisture 3.5%; and S-2, Centennial roots purchased on the open market about 5 months after harvest and processed immediately, moisture 3.9%.

Oxygen Absorption. The Warburg technique was used

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