SYMPOSIUM: MILK LIPIDS

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Introduction to the Symposium on Milk Lipids[1]

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ABSTRACT

Milk lipids, often referred to as "milk fat," have been of interest to man for centuries. Milk fat is a major component of bovine milk and most dairy foods and has the highest economic value of any of the milk constituents. In 1970, over 4 billion pounds of milk fat were produced by 12 million cows in the U.S. Practically all this fat was used in food products and provided ca. 16% of the total visible and invisible fat consumed by Americans. Although milk fat has been the subject of many investigations in the past, there is continuing interest in its complex composition and its chemical, physical and nutritional properties. The purpose of this symposium is to review contemporary knowledge of milk lipids and to focus attention on recent developments of interest to individuals associated with the field of edible fats and oils.

Since prehistoric times, man has satisfied his need for fat by eating foods from a variety of animal and vegetable sources. Among these foods, milk from animals has been a prime source of nutrients. For example, the average composition of cow's milk in the U.S. is 3.7% fat, 4.9% lactose, 3.5% protein, 0.7% minerals and 87.2% water (1). It has been estimated that in 1970 ca. 12.6 million cows in the U.S. produced 117.1 billion pounds of milk containing 4.3 billion pounds of milk fat (2). This latter value compares with 14.6 billion pounds of vegetable oils produced in the U.S. (3).

Traditionally, milk fat has always had the highest economic value of any of the milk constituents with the amount of fat present serving as the usual basis for paying the milk producer. The value of the fat depends on several factors including the type of dairy product to be produced. The average price received by California producers in 1971 for milk fat sold as cream to be churned into butter was 68 cents a pound. This price places milk fat at an obvious economic disadvantage when competing with refined vegetable oils, such as soybean, which cost ca. 15 cents a pound.

In contrast to other animal fats and to vegetable oils, practically all the milk fat produced in the U.S. is used in food products for man. In 1969, 45.3% of the milk fat supply was utilized as market or fluid milk and cream, whereas the amounts supplied in creamery butter, cheese

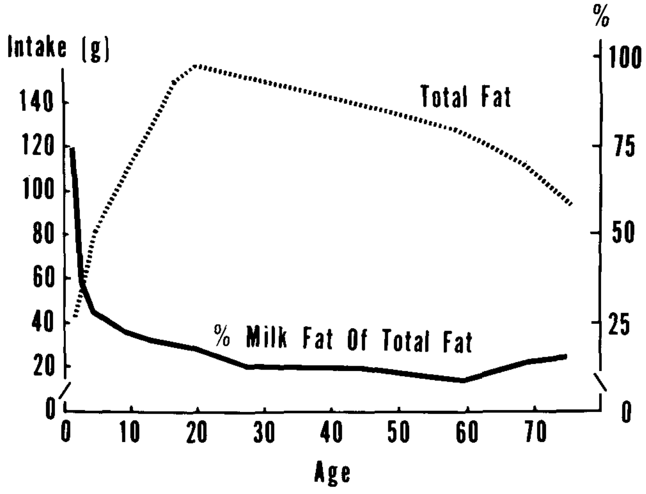

FIG. 1. Total fat from food eaten in 1 day by males of various ages and percentages of total fat supplied by dairy products, excluding butter (8).

[1]One of eight papers presented in the symposium "Milk Lipids," AOCS Meeting, Ottawa, September 1972.

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TABLE I

Disposition of U.S. Milk Fat in 1969[a]

Use	%
Fluid milk and cream	45.3
Butter, creamery	20.5
Cheese	15.4
Ice cream, etc.	9.5
Evaporated and condensed	3.4
Used on farms where produced	3.8
Other uses	2.1

[a]Milk Industry Foundation (4).

and ice cream were 20.5%, 15.4% and 9.5%, respectively (Table I).

In considering the consumption of food fats, it is important to note the distinction between visible and invisible fat sources. Visible fats, including butter, lard, margarine, shortening, and cooking and salad oils, are identifiable as such in the first stage of marketing. In contrast, invisible fats are components of a great variety of foods, including meat, poultry, fish, dairy products (excluding butter), eggs and baked goods. In the U.S., the amount of available food fats per person increased from 115 to 128 lb over the period 1957-59 to 1971 (Table II). During this period, ca. 60% of the fat consumed came from invisible sources. There was an increase in the consumption of vegetable fats in the form of margarine, hydrogenated shortenings and cooking and salad oils from 25 to 35% of the total fat. The percentage of the total fat provided by meat, poultry and fish increased from 33 to 36%, but the percentage contributed by lard declined from 8.1% to 3.4%. Total milk fat consumed as both butter and dairy products declined from 22.2 to 15.5% over the same period. It is interesting that only ca. 20% of the milk fat used in 1971 was consumed as butter.

The amount of fat actually ingested by people in different age groups cannot be stated exactly, and wide variations certainly occur. For example, meats, poultry and fish vary widely in fat content, and the amount of fat actually ingested will depend on whether visible fat is eaten or trimmed off as waste and whether fat drippings are discarded. However milk fat is consumed mainly in dairy foods in which the fat is emulsified and is not readily separable. A detailed analysis of problems involved in determining how much fat Americans use currently and have used historically has been presented by Call and Sánchez (7).

In the spring of 1965, the USDA conducted a nationwide household-food-consumption survey in which information was obtained on the daily food intake of individual members of ca. 6200 representative households. Food consumption recorded was food actually eaten (8). Trends in the average fat intake by males in various age groups are indicated in Figure 1. Total fat intake increased rapidly with age to a peak of 155 g at age 18-19, after which it declined slowly to ca. 95 g at 75 years and over. Milk fat intake excluding butter declined from 31.5 g during the first year to 22.7 g at age 3-5. It then increased with age to a peak of 29.5 g at age 15-17. After the teenage years, milk fat intake declined very slowly from 17.6 to 12.5 g at 75 years and over. The percentage of the total fat intake accounted for by milk fat declined rapidly from 73% at under 1 year of age to 23% at 9-11. During the teenage years, the percentage remained ca. 20% but was relatively stable at ca. 11% during the 20-64 year bracket. At age 70 it had increased to slightly over 13%.

This information on the production of milk fat and trends in its consumption should provide a useful background for this symposium, which will emphasize biological, chemical, technological and nutritional aspects of milk lipids.

There is no precise definition of the term "lipids." However they are generally considered to include a broad group of compounds present in living organisms that are insoluble in water but soluble in the so-called fat solvents. The term "fat" is often used interchangeably with lipid and will probably be used in the nutritional labeling of foods to describe all material soluble in fat solvents. Some scientists prefer to limit the meaning of fat to "a glyceride in the solid state." In the dairy industry, the term "butterfat" has been used when analyzing milk and milk products for fat content. Anhydrous butterfat is a commercial product made directly from milk or cream. Butteroil is a similar commercial product made by removing water from butter. When discussing the chemistry and nutritional value of dairy products, use of the terms milk fat and anhydrous milk fat is recommended.

The lipids in milk exist as microscopic globules in an oil-in-water emulsion. Each globule consists mostly of triglycerides but a complex mixture of other lipids is associated with it, especially at the surface. The structure of the globule and how it is produced in the mammary gland has intrigued scientists since the time of Leeuwenhoek, who first described its presence in cow's milk about 1700. Stuart Patton, who has extensively investigated the complex mechanisms involved in milk secretion, discusses the latest findings relative to the origin of the milk fat globule and the structure of the globule membrane (9).

The lipids of milk include a broad spectrum of classes of lipids that differ in their chemical nature. Glycerides and phospholipids are of special interest and these, in turn, contain an amazing variety of constituent fatty acids. Unsaturated fatty acids in feeds are normally hydrogenated in the cow's rumen through the action of microorganisms and then incorporated into milk lipids. Recently Australian scientists demonstrated that feeds containing encapsulated or "protected" polyunsaturated oils can be protected from hydrogenation in ruminants, thereby changing the fatty acid composition of milk fat. Robert Jensen reviews the composition of milk lipids and recent findings concerning the composition of lipids from cows fed "protected" oils (10).

The study of triglyceride structure, i.e., the distribution of fatty acids in the three positions of individual glycerol molecules, is a particularly difficult research field. This is especially true in the case of milk triglycerides which have a very complex fatty acid composition. Arnis Kuksis (11), who has used a combination of modern analytical methods to assess the stereospecific distribution of fatty acids in milk fats, presents his findings.

The physical properties of milk fat are important in determining its utilization in dairy and other foods. Limited variations in physical properties can be made by modifying crystallization of the fat during processing, e.g., temperature treatments of cream before churning of butter. Because the range of properties possible is comparatively limited, there has been continuing interest in methods to obtain milk fat fractions suitable for specialty uses in foods and confectionary products. In this symposium, John Sherbon reviews recent progress in understanding milk fat crystallization and fractionation. He describes commercial methods of fractionation including the new Alfa-Laval system (12). Another approach to greater utilization of milk fat is to modify it chemically by interesterification or hydrogenation. Smith and Vasconcellos report research on the use of palladium and nickel catalysts to hydrogenate milk fat (13).

Fresh milk and milk fat normally have mild, delicate flavors. However milk fat can be the source of a multitude of flavor compounds that may result in desirable flavors or in undesirable off-flavors. The isolation, separation and

TABLE II

U.S. Consumption of Visible and Invisible Food Fats per Person[a]

Source	Pounds per person		Percentage distribution	
	1957-59	1971[b]	1957-59	1971[b]
Visible fats[c]				
Butter (fat content)	6.6	4.1	5.7	3.2
Lard (direct use)	9.3	4.4	8.1	3.4
Margarine (fat content)	7.2	9.0	6.3	7.0
Shortening	11.4	17.0	9.9	13.3
Other edible fats and oils	10.8	18.6	9.4	14.5
Total visible	45.3	53.2	39.4	41.6
Invisible fats				
Dairy products (excluding butter)	19.0	15.7	16.5	12.3
Eggs	4.6	4.1	4.0	3.2
Meat, poultry and fish	38.0	46.0	33.0	36.0
Dry beans, peas, nuts, soya, flour and cocoa	5.3	6.1	4.6	4.7
All fruits and vegetables	1.0	1.1	0.9	0.9
Grain products	1.7	1.7	1.5	1.3
Total invisible	69.7	74.7	60.6	58.4
Total fats and oils	115.0	127.9	100.0	100.0

[a]USDA, "National Food Situation" (5,6).
[b]Preliminary.
[c]Identifiable as such at the first stage in marketing channels.

identification of flavor compounds has developed into a highly specialized field. Daniel Schwartz, who has made extensive contributions to the various techniques needed to study the complex mixture of flavor compounds and trace constituents present in milk fat, describes new methods of isolation and characterization (14).

Finally, all of these subjects are relevant to Fred Mattson's interest in the nutritional significance of fatty acids and cholesterol. He discusses current recommendations for changes in the level and in the composition of fats consumed in Canada and the U.S. (15).

This represents a bird's eye view of the symposium program. Hopefully it will be both informative and interesting and will provide additional stimulus to other scientists to further knowledge of the composition and properties of milk lipids.

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