Modification of Food To Control Fat Intake[1]

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ABSTRACT

National trends in amounts and types of fat consumed have not alleviated our problems in nutrition and health. The dilemma of the public, as well as of the medical and nutritional sectors of society, has been what to do about atherosclerosis and obesity. Various methods and approaches are suggested whereby the fat intake may be reduced or controlled. Several unique classes of compounds are suggested as possible candidates for novel nutritional foods. Nutritional education is stressed as the long range prerequisite for an enlightened public which can meet the challenge of tomorrow.

INTRODUCTION

Data are available on the fat and oil consumption, as well as the trends of specific oil utilization in the U.S. (1-4). We must assume that what is sold and disappears from the market place is consumed by the public. If one watches the food discarded in homes, restaurants, and mess halls, however, one might not agree that the food is consumed. The figures we have, however, do serve as a guide and approximations for our discussion.

The literature is also voluminous on the views and teachings of many who believe that there is a direct correlation and influence of fats and oils on health (5-7). Some views of the controversy and debate have not resolved themselves in over a quarter of a century and probably will not be resolved for many more years to come.

We do not have any assurances that, by following the best recommended food practices, one can ensure good health and longevity. We do know, however, that the recommendations of the nutritionist are observed by less than 5% of the population. When our appetencies and nutritional guidelines come into conflict, usually the public has seen fit to satisfy their appetencies.

[1]One of five papers presented a the symposium, "Status of Fat in Food and Nutrition," AOCS Fall Meeting, Chicago, September 1973.

PROBLEM AREAS

One of the major hurdles we face in our attempts to eliminate such problem areas as atherosclerosis and obesity is the fact that we still do not know the real causes for the conditions. Atherosclerosis and the entire area of coronary problems is still controversial. It has resolved itself into an ever growing list of risk factors, irrespective of whether such factors are causes or effects. The role of polyunsaturated fatty acids and their ratio to saturated fatty acids in an oil is still questionable even after some 25 years of clinical investigations and studies. Recent publications (8,9) are seriously questioning and critically examining the literature and the experimental design of the studies which gave us simple, convenient answers to a most complex problem.

The other problem area is obesity. Conservative estimates by the U.S. Department of Agriculture and the American Medical Association indicate that over 30 million people in the U.S. are overweight, if not outright obese (10,11). We do not have an easy solution to the problem of overeating, diet fads, and wt control efforts. The problem is a much more fundamental one in nature. What determines obesity? Is it genetic, geographic, or dietetic? Why do fat cells multiply manyfold in some and not in others? Why do the cells fill up with fat in some and remain empty in others? Hopefully, we shall get some answers to these questions in the near future. In the meantime, controlling caloric intake has become the suggested way to lose wt if one can only have the willpower to discipline himself.

In attempting to focus attention on nutrition, the various governmental agencies, notably the Food and Drug Administration, have been promoting nutritional labeling of foods. If the public comes to think in terms of nutrition and good health, perhaps they will improve their eating habits. It seems, however, that the main thrust should be nutritional education and not a labeling scheme. It is only through an enlightened and educated public that we can hope to bring about balanced and controlled food intake to ensure good nutrition and good health.

LIMITING FAT INTAKE

In recent studies on the fat intake of the American

TABLE I

U.S. Consumption of Visible and Invisible Food Fats/Person (2)

Source	Lb/person 1971[a]	Percentage distribution 1971[b]
Visible fats[b]		
Butter (fat content)	4.1	3.2
Lard (direct use)	4.4	3.4
Margarine (fat content)	9.0	7.0
Shortening	17.0	13.3
Other edible fats and oils	18.6	14.5
Total visible	53.2	41.6
Invisible fats		
Dairy products (excluding butter)	15.7	12.3
Eggs	4.1	3.2
Meat, poultry, and fish	46.0	36.0
Dry beans, peas, nuts, soya, flour, and cocoa	6.1	4.7
All fruits and vegetables	1.1	0.9
Grain products	1.7	1.3
Total invisible	74.7	58.4
Total fats and oils	127.9	100.0

[a]Preliminary.

[b]Identifiable as such at the first stage in marketing channels.

TABLE II

Fatty Acid Composition Changes in Shortenings and Margarines (12)

Fatty acid type	Shortenings (%)		Margarines (%)		
	Old type	New type	Old type	New type	Tub
Saturated	27	25	22	20	13
Monoenoic	61	47	63	50	23
Polyenoic	12	28	15	30	64

public, it has been shown that the visible fat intake constitutes ca. 40% calories. Our total fat intake, visible and invisible, is probably closer to 60% calories. Table I illustrates the U.S. consumption of visible and invisible food fats/person. It is much too high and should be reduced to perhaps 30-35% total caloric intake. Perhaps with a concerted national effort and with emphasis at the grade school level, we can educate the future generations and the public to the basic principles of good nutrition, balanced food eating habits, and even controlled food intake. In such education and efforts, we also may broaden our vision to other foods and other raw materials for food, rather than the established standard products. A variety of meat sources, legumes, and grains may be necessary in our economy of the future, not only to feed us but to keep us healthy.

Examples of Limiting Fat Intake

In our efforts to limit or curtail our fat intake, some examples are possible to illustrate the point. These are presented below.

The selection, breeding, feeding, and preparation of meat from various domesticated animals for public consumption can be controlled for lean low-fat content meat products. Simple trimming and fat removal, and even skimming during preparation and use of foods, also can contribute to lowering the total fat content of our foods.

The deep fat fried peanuts and the dry roasted peanuts may well give way to the defatted roasted peanuts. The defatted roasted peanuts have appreciably lower fat and calories and yet are tasty and satisfying.

Low fat milk, now has established itself along with homogenized milk. The 1 and 2% fat milk satisfies the nutrition and milk drinking needs while decreasing the total fat and caloric intake.

Diet margarines, where the fat content has been reduced to 40% from 80%, are now a reality. It should satisfy our desire to spread the margarine on toast or baked potato and yet curtail our fat and caloric intake.

Diet mayonnaise and salad dressings have made their appearance and are gaining acceptance. This is still another example of satisfying our appetencies while curtailing fat and caloric intake.

Mellorine and imitation ice cream with lower fat content, and some without any fat, are making their appearance and gaining good acceptance. They taste good, satisfy our desire to eat rich desserts, and yet contribute limited amounts of fat and calories. Perhaps it is a way of fooling oneself and indulging rather than abstaining, but it seems to be more acceptable.

TABLE III

Composition of Some Formulated Foods[a]

Ingredient	Beef flavor	Ham flavor	Chicken flavor
Protein	20	24	25
Fat	4	13	12
Moisture	60	55	55
Ash	3	3	3
Carbohydrate (by difference)	13	5	5

[a]Given in percentages.

TABLE IV

Composition of Some Natural Meats[a] (13)

Ingredient	Beef		Ham	Poultry
	Carcass	Hamburg		
Protein	16	18	15	18
Fat	52	21	30	18
Moisture	31	60	54	63
Ash	1	1	1	1

[a]Given in percentage.

Formulated Foods

The food industry, particularly the fats and oils segment of that industry, has given way to the demands and the insistence of the medical forces and the consuming public. They have supplied products with higher polyunsaturated fats in the formulations of foods, such as shortening, margarine, salad oils, dressings, etc. Table II (12) demonstrates the shift that has taken place in shortenings and margarines. Whether this is a step in the right direction still remains to be seen. Certainly the clinical evidence of the last 25 years has not overcome the controversy that still exists. It would be more prudent if we learned to eat less and eat less fat while keeping a balanced diet.

In the area of formulated foods where the composition is subject to our control, it should be feasible to restrict the fat content of a food and still have it palatable and appetizing. Table III illustrates some formulated foods simulating conventional meats, but with fat contents appreciably lower than natural meats. We have prepared and evaluated these products in acceptance studies where both the product and the type of fat used were variables. In such products, the type of fat and the amount of fat can be controlled without any sacrifice to the quality of the food

TABLE V

Caloric Value Constants on Polyglycerol Esters
Caloric Value Expressed in Kg Cal/g Mol Wt

Glycerol type	No Ester	Mono-Ester	Di-Ester	Tri-Ester
Glycerine	4.28	8.49	9.15	9.43
Diglycerol	4.65	8.22	9.01	9.34
Triglycerol	4.93	7.77	8.73	9.21
Tetraglycerol	5.00	7.43	8.41	8.93
Pentaglycerol	5.04	7.17	8.14	8.61
Hexaglycerol	5.07	6.97	7.92	8.39
Heptaglycerol	5.10	6.82	7.72	8.21
Octaglycerol	5.12	6.67	7.56	8.06
Monoglycerol	5.13	6.55	7.43	7.90
Decaglycerol	5.15	6.46	7.24	7.77
Triacontaglycerol	5.24	5.65	6.04	6.35

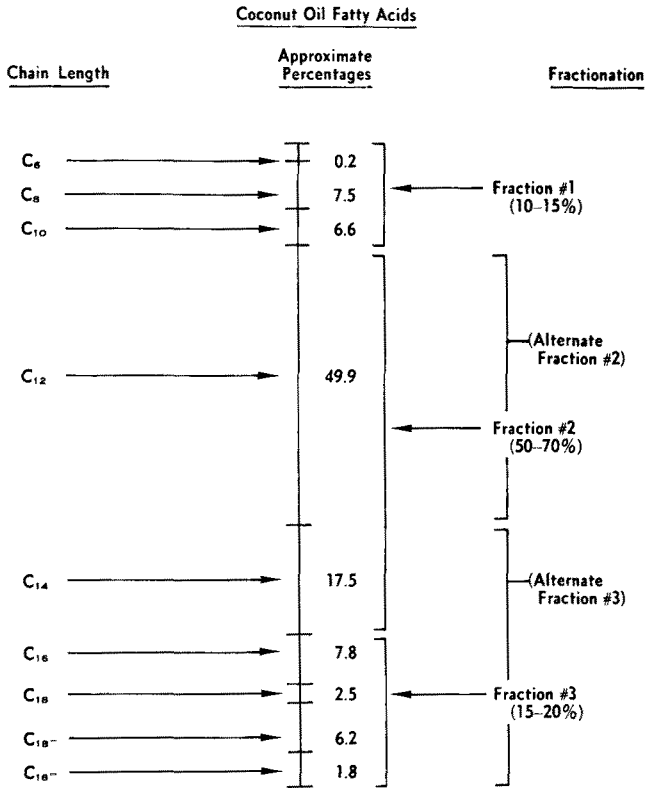

FIG. 1. Medium chain triglycerides–their composition, preparation, and application (17).

produced. Table IV (13) illustrates, by contrast, the fat level of the natural meats. Not only is the fat content much higher, but we do not have much flexibility and choice in the type and amount of fat present in the product. Similar products of limited fat content and type of fat present can be arranged in such products as desserts, toppings, and similar rich foods. The connotation is one of high fat, high calories, and, yet, products of low fat, low calories, are offered with the help of such emulsifiers as the polyglycerol esters.

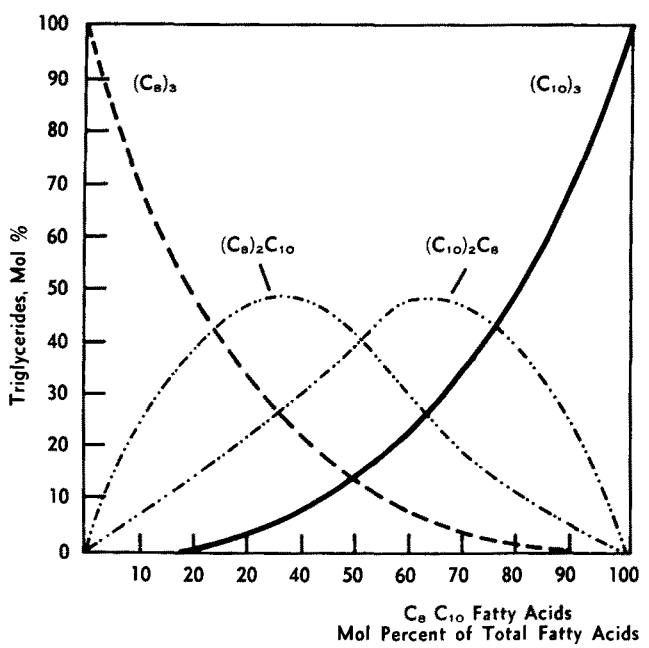

FIG. 2. Medium chain triglycerides–their composition, preparation, and application (17).

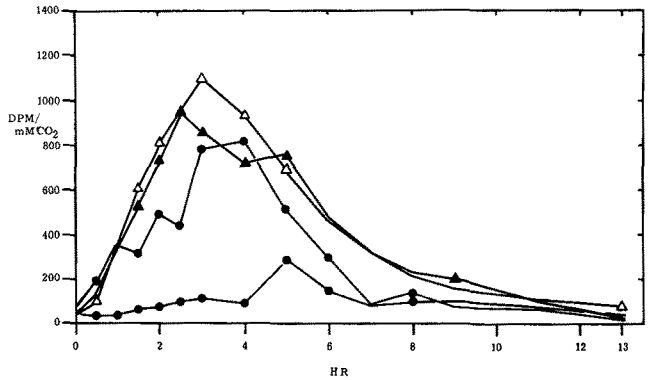

FIG. 3. Oxidation and metabolism rates of glucose, medium chain triglycerides, and long chain triglycerides (20). △ = glucose in 20 fat free milk, ▲ = glucose in 20 medium chain triglycerides, ● = trioctanoin in 20 medium chain triglycerides, and ● = stearate in 20 long chain triglycerides.

TAILOR-MADE FATS

Medium Chain Triglycerides

One of the new exciting areas of tailor-made fats which tend to supply fuel and energy while having a very low tendency to deposit as depot fat are the medium chain triglycerides. Over the last 20 years, their uses in medicinal and clinical applications have become well established (14-16), but their application and use in consumer products is just emerging.

If we look at the coconut oil fatty acid profile in Figure 1, we find it to be a good source of C_6-C_{10} acids. By splitting, distilling, and fractionating such acids, we arrive at a feedstock for such medium chain triglycerides. When such C_8-C_{10} acids are esterified with glycerine, we have the mole ratio distribution based upon the fatty acid composition of the feedstock, as illustrated in Figure 2 (17).

Medium chain triglycerides have been proposed and clinically used for therapeutic applications for a variety of conditions, including pancreatic insufficiency, decreased small intestine surface, bile duct obstruction, and other liver disease, sprue, steatorrhea, lipoproteinemia, and lymphatic obstruction. Their value in treating these conditions depends upon the greater water solubility and smaller molecular size of the medium chain fatty acids, compared to the long chain fatty acids (15,18,19). The long chain fatty acids are absorbed entirely through the lymphatic pathway, whereas the medium chain fatty acids and glycerides are absorbed via the portal vein which takes them directly to the liver. In the liver, they are oxidized and

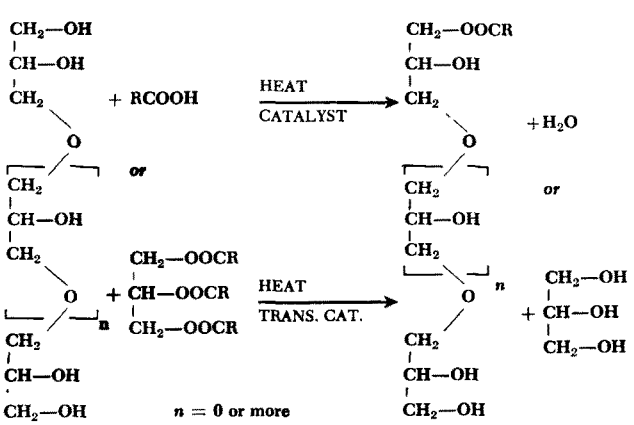

FIG. 4. Synthesis of polyglycerol partial ester (23). R may be saturated or unsaturated, aliphatic or aromatic, monocarboxylic or di-, and polycarboxylic may form mono- or polyester.

metabolized rapidly, providing fuel and energy without depositing in adipose tissue (18).

The medium chain triglycerides recently have been shown to be oxidized and metabolized as rapidly as glucose while contributing twice the calories of glucose (20,21). The work of Shah and Iber (20) with double-tagged radioactive molecules demonstrated clearly that such medium chain triglycerides are, indeed, oxidized and metabolized as rapidly as glucose, while long chain triglycerides (corn oil), by contrast, are oxidized and metabolized slowly and in much lower amounts. Figure 3 is typical of the four series of patients studied where the medium chain triglycerides demonstrated their unique properties. Within 30 min of ingestion, the medium chain triglycerides were found in the blood stream of the patients. It reached peak utilization within 2-1/2 hr, keeping an even pace with the rate of oxidation and amount of utilization of glucose. The corn oil (long chain triglyceride), in contrast, reached a peak in 5 hr, but even its total uptake after 13 hr was only ca. 15% ingested amount. Glucose and medium chain triglycerides were three-five times greater in total amounts of corn oil utilized.

The four series of experiments run on humans tested were: (A) medium chain triglycerides vs milk fat, (B) medium chain triglycerides vs corn oil (long chain triglycerides), (C) medium chain triglycerides vs glucose, and (D) medium chain triglycerides vs fat-free diet.

In each of the series, the pattern was similar to that shown in Figure 3 where the glucose and medium chain triglycerides were rapid in their entering the blood stream and rapid in their oxidation and metabolism, as indicated by the expiration of the radioactive CO_2 collected. In contrast, corn oil was always very slow in absorption and in very low order of oxidation and metabolism, even after 13 hr of ingestion.

What we are witnessing is a new phenomenon. A tailor-made fat, having a high caloric value, is absorbed, oxidized, and metabolized as rapidly as glucose. What makes this tailor-made fat even more unique is the fact that, over the last 20 years, data have developed to show several striking characteristics for this fat over and above its rapid absorption and metabolism. Kaunitz and coworkers (as well as O. Mickelsen, private communication) have shown on animal studies that the medium chain triglycerides have a very low tendency to deposit as depot fat in contrast to conventional fats. Kaunitz and coworkers also have shown that, in such studies on mice, rats, and monkeys, although one obtains the typical serum cholesterol levels for lard, corn oil, and medium chain triglycerides, when such animals are sacrificed and total cholesterol is determined on liver, arteries, and heart, a consistent picture evolves. The lard and corn oil animals have cholesterol levels always within 5% of the total cholesterol levels found for the two groups. This difference is not statistically significant. The medium chain triglyceride animals, however, always show some 40-50% lower total cholesterol levels. This is statistically highly significant.

Perhaps it is in the context of all these unique characteristics of the medium chain triglycerides that we must consider their use in consumer products for tomorrow. Perhaps the formulations of foods should consider specific types of fat as the alternatives to the conventional fats, not on the basis of saturate-polyunsaturate, but rather on their impact on controlling the deposition of fat and the deposition of cholesterol. Such a novel approach for use of tailor-made fats for food products deserves serious consideration for our future nutritional needs.

Polyglycerol Esters

The other unique class of compounds in tailor-made fats are the polyglycerol esters (22). They are really hybrid fats

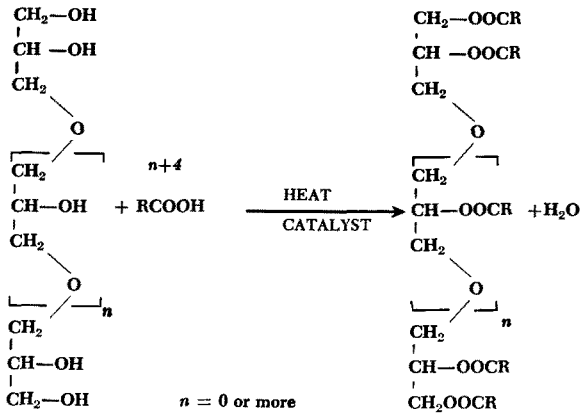

FIG. 5. Synthesis of polyglycerol complete ester (23). R may be saturated or unsaturated, aliphatic or aromatic, or one or more fatty acids.

with fatty acid side chains and a polyglycerol backbone. Such products look and taste like fats and oils but contribute fewer calories than the customary and conventional fats and oils. Figure 4 illustrates the two conventional methods for producing polyglycerol partial esters. Depending upon the polymer chain length of the polyglycerol and the number and type of fatty acids used in esterification, one is able to produce a vast array of products of various physical and chemical characteristics. If all of the free hydroxyl groups are esterified, then neutral esters, as shown in Figure 5, are formed. They represent high mol wt oils with good stability and texture (23-25).

For fat and calorie restriction, however, it is the partial esters, as shown in Table V, which we should consider. The mono- and diesters of such polyglycerols range anywhere from 6-8.5 calories/g, as compared to the 9.2 calories/g for the conventional fats. These partial esters also have the unique characteristic where the use of a small amount in an aqueous emulsion gives one the palatable satisfaction of eating rich, creamy foods. Such products should be considered in our nutritional evaluation and caloric intake control. They certainly offer a new approach and novel products for food applications. The polyglycerol partial esters offer a versatility and flexibility in physical and chemical variation which lend themselves to our formulation needs in food products with the unique characteristics.

In our outlook for the foods of tomorrow and the modification of food to control fat intake, we must search for the unique. The key to our success and utilization of such new food sources still will come back to education. An informed, educated, and knowledgeable public is the best insurance we have to overcoming the problems of atherosclerosis and obesity. Good nutrition and good health can follow good eating habits if we have the will to face the challenge.

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