# Fats in Nutrition and Health Symposium

## Introduction

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*WE are pleased to present a symposium on a subject important to us as individuals and of vital importance to the industries represented in the membership of the American Oil Chemists' Society. The purveyors of fats and oils have a record of improving continuously the quality and appeal of fat products. More appetizing dishes can now be prepared, and more stable fat products are available in physical forms most convenient for use. This has been accomplished through improvements and advances in the chemistry and technology of fats and oils. Fats and oils have become a means for making more food more palatable and appetizing.*

*The current discussions on the relationship of quantity and type of fat in the diet to nutritional and medical problems cannot help but affect the fats and oils indutry. This industry is anxious to adjust its products to the best nutritional advantage of the consumer but, in the welter of confusion on this subject, cannot find any clear notion whether or not to turn or in which direction. For this reason we organized this symposium and have invited outstanding scientists in the fields of fats and oils, nutrition, and medicine to present a sober analysis of the situation and trends. We hope that this discussion will help to clarify the issues involved and will enable you to follow more clearly the continuation of research and discussion on this subject.*

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# Fats in Nutrition and Health[1]

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ALTHOUGH the chemistry and nutritional role of fats and oils did not receive wide recognition among scientists as early as their importance deserved, there is no doubt of their conspicuous position now. This new emphasis upon lipide research is equally characteristic of scientists engaged in pure research and of those who are primarily concerned with practical problems in industry, public health, and agriculture.

**C. G. King**

In the light of present events there is an element of humor in noting that the fats were the first of the major groups of nutrients to be identified chemically, and the chemist who made this discovery (Chevreul, 1814) lived to be more than a hundred years of age. I have found no indication of his having been either overweight or handicapped by atherosclerosis.

Why is there so much interest in fats today? Basically, I believe it is because research scientists have discovered only recently how closely lipide metabolism is interwoven with a) our major problems in public health and b) a greater number of organized enzyme-reactions that characterize all living organisms.

Meanwhile we have trained too few scientists who have given their major attention to research on problems of the nature that are now coming to light. Discovery that one of the vitamins, pantothenic acid, and a whole group of metallic catalysts, such as copper, iron, and molybdenum, play key roles in the synthesis and degradation of fats has greatly stimulated the interest of biochemists and nutritionists in this area of investigation.

[1] Presented at the annual meeting, American Oil Chemists' Society, New Orleans, La., April 30, 1957.

### Nutritional Requirements

During our present period of unbridled and excessive publicity about the place of fats in the diet, we have need to keep greater emphasis on the fact that fats should be in the diet regularly. Normally they are both safe and physiologically desirable. They are a source of both pleasure and efficiency in preparing and consuming food. Although the evidence concerning requirements for fat in human diets still rests largely on analogy to studies with experimental animals, enough evidence is available from careful observations and direct human experimentation so that few people would disagree with the view that glyceride types of fats and oils should be regarded as essential ingredients in human diets.

The need for an adequate supply of fat-soluble vitamins (A, D, E, and K) has been long recognized. Gradually, through the work of Burr and others, the evidence has become generally accepted that there is an essential requirement for one or more fatty acids if one is thinking in terms of optimum nutrition. But the concept of balancing the quantitative intake of different types of fatty acids against each other and against other types of nutrients, such as proteins, sugars, vitamins, and minerals, to achieve physiological efficiency presents a relatively new situation.

With respect to stating an optimum intake of dietary fats the Food and Nutrition Board of the National Research Council has been wrestling with this problem for several years. The tendency to adopt an average opinion in a field where the evidence is relatively limited may not result in the best answer. At the present time however opinions differ widely among relatively competent investigators. If we rely on data from observations on human subjects for a primary guide in searching for an ideal fat-intake,

the estimates range from 20 to 45% of total calories. Obviously these estimates mean very little unless one also has in mind the specific ingredients of the fat consumed and many related variables. Among the variables that may affect the apparent result are such items as the quality and quantity of protein intake, the energy expenditure, the consumption of vitamins $B_6$, C, E, riboflavin, inositol, and choline, the humidity and temperature of the atmosphere, the age and sex of the individual, and the degree to which the diet as a whole is balanced. Furthermore the requirement for and tolerance of fat by different species of animals are now known to vary over a wide range. For example, the tolerance of chickens for common edible fats is much lower than the human tolerance, in contrast to the greater tolerance of rats.

In the 1953 issue of Recommended Dietary Allowances prepared by the Food and Nutrition Board of the National Research Council we find only two short and noncommittal paragraphs dealing with fat. Both paragraphs can be summarized in two sentences.

> While a requirement for certain unsaturated fatty acids, notably linoleic and arachidonic acids, in natural fat has been demonstrated with experimental animals, the human need for these fatty acids is unknown. In any event, adequate amounts are readily available in ordinary diets, in which fat provides as much as 20% of the total calories.

In planning for a revision of the Recommended Dietary Allowances during 1957, the section on fats probably will be rewritten, but a final decision has not yet been reached on the exact wording.

The Department of Agriculture, after an extensive survey of dietary practices in the United States, has estimated that the intake per capita in recent years has been about 41% of total calories. Some estimates have been higher and others have been lower, but I think the U.S.D.A. estimate is reasonably accurate. Their data also agree with the estimate recently suggested by the group at Harvard University. Some of the earlier estimates pointed toward a marked increase of fat consumption in the United States, but the records were often incomplete with respect to waste during preparation, plate waste, and diversion in usage, such as feeding dogs and cats. Apparently individual variations in the waste of fats is about as great as the evident variation in fats of the waist. In any event, the change in total fat consumption per capita during the past 20 years does not seem to have been enough to constitute a major factor in public health.

Beyond the question of total fat intake there is a growing interest in the relative and absolute intakes of the three polyunsaturated fatty acids: linoleic, linolenic, and arachidonic. Again, estimates by the Department of Agriculture and others do not indicate that a major change has occurred in this regard. But others believe there has been an increase in the intake of the saturated fats, and the press has been generous in transmitting their alarms. Claims of this nature are made on the postulated basis of both an increased absolute intake of saturated fatty acids and a relative increase, compared with the intake of polyunsaturated fatty acids. It should be recognized however that there has been an increased consumption of oils and fats from plant sources that have been only partially hydrogenated and hence retain an estimated 30 to 50% of their original linoleic acid content. (Chemical and biological assays may differ considerably.)

It may well be true that a decreased physical energy output as a result of less manual work and exercise by many individuals in recent years has been a more important factor than the changes in dietary fats.

### Better Diets

It is probably true that, in parallel with the economic improvement of the lower income groups in the United States during the past 20 years, there has been some rise in the percentage of total calories derived from fat because most people like foods containing fat. In the over-all picture however there has been a notable advance in the nutritive quality of foods consumed by both low and high income groups. Hence there should have resulted a gain in fat tolerance. For example, the survey just completed by the Department of Agriculture indicates that in contrast to conditions 15 or 20 years ago, when one-third of the population consumed diets rated as "poor," only one-tenth of our families could be so rated by the same standards in 1955.

### Research Trends

With respect to the three fatty acids of primary importance: linoleic, linolenic, and arachidonic it is apparent that, in a practical sense, linoleic acid is in a position of dominant importance both because of its wide distribution in edible fats and because of its capacity to be converted to the other fatty acids, including arachidonic. Its effectiveness in lowering the concentration of serum cholesterol has been demonstrated also in tests with a great variety of human-dietary patterns and in many different species of animals.

There is increased interest in arachidonic acid also because of the growing evidence of its content and probable essentiality in glandular and nerve cells and the more recent evidence of its constituting a part of important enzyme systems (*e.g.*, cytochrome oxidase in heart muscle and brain). This new relationship may furnish a further clue to the apparent role of vitamin $B_6$ in forming arachidonic acid and to the many close relationships with other nutrients, such as methionine, choline, and riboflavin.

Beyond the general practice of consuming a varied and well-balanced diet regularly, keeping the body weight near the ideal for each person, and taking reasonable care to use foods that furnish an adequate intake of linoleic acid, there does not seem to be any basis for recommending to the public radical or extreme changes in food practices relative to fats. The advice of a physician in the personal care of a patient represents a very different situation. In this relationship, of course, the physician should be free to recommend experimental diets and other practices that are not recommended for the general public.

Examples of quantitative information that is seriously needed as a basis for practical guidance in fat consumption are as follows:

a) the relation of caloric intake from all sources to an ideal, quantitative intake of linoleic acid when the diet as a whole is well balanced,
b) the quantitative relation of linoleic acid to the tolerance of total percentage of calories supplied specifically as fat,
c) the relative position of oleic acid in exerting a favorable or unfavorable effect on the apparent need for linoleic to balance the effect of saturated fatty acids (as a factor in regulating serum cholesterol concentration),
d) the approximate quantity of linoleic acid that is optimum for reversing cholesterol deposition if such an action is possible,

e) the effect of quality and quantity of protein intake within a given range of caloric intake that is favorable to regulating cholesterol at normal levels,
f) the effect of different levels of vitamin $B_6$ intake on the optimum intake of individual fatty acids, including linoleic, arachidonic, oleic, and saturated types,
g) the long-term effects of mineral intake, as in the case of magnesium, copper, and molybdenum, on fatty acid tolerances and requirements,
h) the degree in which fatty acid isomers of *cis-* and *trans-*configuration and with different positions of double bonds in the carbon chain affect the metabolic balances of cholesterol and other lipides,
i) the tolerance range where chain length of saturated fatty acids may become an important factor in cholesterol regulation or in other aspects of fat metabolism,
j) the effects of food-fat composition and quantity upon blood-clotting regulation (this should include both clot formation and reversal),
k) the effect on fat metabolism of nonsaponifiable food constituents, such as plant sterols, selachyl alcohol, and squalene,
l) and (perhaps as important as any other factor in relation to fats) how in the world can people be saved from the sin of persistently eating more calories than they need?

The above list of suggestions could be greatly extended, but perhaps it will serve to indicate the need for basic information to furnish a practical guide to industry, to the medical profession, to educators, and to those who are concerned broadly with problems of food production and public health.

### Death Rates from Heart Disease

Now turning briefly to public health aspects of fat intake and metabolism, I would first like to quote from a recent paper by Edward A. Lew, statistician of the Metropolitan Life Insurance Company (publication dated January 15, 1957, entitled "Some Implications of Mortality Statistics Relating to Coronary Artery Disease"). From an extensive study of vital statistics Dr. Lew arrived at the following conclusions. They differ sharply from the impression one would gather from current discussions in the press and in many technical papers with respect to the incidence of coronary artery disease.

> My principal conclusion is that the real increase in mortality from this disease (coronary heart disease) during the past 15 years has been relatively small, certainly not of the magnitude to justify the alarms expressed in the press and elsewhere.
>
> . . . about 30% of the increase from 1940 to 1955 in the crude death rates from coronary disease can be accounted for by the greater proportion of persons at the older ages. Another 40% of the increase can be ascribed directly to the changes in procedures and classification adopted in 1949. In my judgment, a major part of the remaining 30% represents merely the acceptance of a broader concept of coronary disease, better diagnosis, and increasing usage of the term coronary artery disease in certifying causes of death. In other words, probably less than 15% of the increase in the death rate can be attributed to a real increase in the mortality from this disease.

Actually, during each of the past three years, the death rate from heart disease in the United States has decreased slightly.

The two highest correlations between death rates from coronary heart disease and other factors cited by Dr. Lew were, respectively: a) for those who reported two or more deaths from cardiovascular disease within their famillies, the death rate was 1¾ to 2½ times the rate for "standard risks;" b) and for the "age group 50–54, the coronary disease death rate among those smoking a pack or more of cigarettes a day was nearly 2½ times as high as the rate for non-smokers" (1). Among overweight men and women the rates were 40 and 60% higher, respectively, when moderately or markedly overweight.

Gross overweight in terms of obesity is associated with an increased incidence of most of the diseases that are prominent as causes of death in America today, including coronary heart disease, cancer, cardiovascular disease (of the kind that often results in brain lesions or "strokes"), diabetes, liver disease, risks of surgery, and many others. The degree to which variations in fat intake, *per se,* can be identified as causative in any of these diseases however is still uncertain in the opinion of our leading physicians, statisticians, and nutrition scientists who are studying the related problems.

During the past few months I have attended a number of conferences at which leading medical and public health authorities in the United States and Canada discussed their evaluations of the current evidence bearing on the consumption of edible fats and the resultant impact on public health. In every group discussion thus far the opinion has been almost unanimous that there was insufficient evidence to justify recommendation of any major departure from what we have regarded in recent years as a well-balanced diet. There is general agreement that "overweight" in terms of excess body fat represents statistically a serious risk to health. Fortunately, relatively simple techniques are now available to identify true obesity. The skin-fold test is useful in field surveys and in simple physical checkups. Measurement of body specific gravity and other techniques are available for more exact research purposes.

In the opinion of statisticians, genetic trends are a very important factor in the incidence of heart disease, diabetes, atherosclerosis, and cerebral hemorrhages. Nevertheless, insofar as nutrition can affect the course of a disease influenced by genetic characteristics, every effort should be made to afford protection. In this sense, whether one is studying controlled animal experimentation or observing changes in human physiology, there is a marked association between trends in health and the tendency to accumulate excessive concentration of cholesterol. Most of the studies of fat intake in relation to health have been interpreted in terms of changes in serum-cholesterol concentration, on the assumption that this trend is a true index of long-term effects on health. One must have some sympathy with this point of view as a working hypothesis until further information is available. However, in the case of the cardiovascular diseases, including coronary heart disease, most of our medical research scientists still hold the view that moderate changes in the serum-cholesterol level, unless supported by additional data, such as increased blood pressure, should be regarded only as a tentative index of favorable or unfavorable trends. As stated previously, this view does not in any sense imply disagreement with the accepted philosophy that, in the care of an individual patient, physicians should be accorded the privilege and responsibility that they have always had in advising a course of experimental therapy or precautionary dietary program.

### Fads Are Not Safe

Extreme dietary practices and faddist recommendations are likely to result in more harm than good. This is especially true with respect to the regular intake of good-quality protein foods, such as meat, milk, poultry, eggs, and fish. These foods should be used regularly and in variety along with normal

quantities of the cereal type of foods, green leafy and yellow vegetables, and specific types of fruits or vegetables that would furnish an assured intake of vitamin C. In the preparation of these foods in an attractive form there is no reason why edible fats should be avoided except in the sense of safeguarding the total intake of calories. The animal protein foods indicated above are not only essential, in a practical sense, but they are also among the most important sources of vitamins and minerals in establishing an over-all balanced diet.

Again, blanket claims that animal fats, or plant fats, or processed fats should be eliminated cannot be justified at present. Each type can furnish essential fat-soluble vitamins and a desirable balance of fatty acids, and it is also true that each type can include fats that are completely lacking in fat-soluble vitamins or favorable fatty acids. Deuel and many others have shown, of course, that fats containing fatty acids which cause a very high melting point tend to decrease somewhat the efficiency of digestion. On this score however, it is important to remember that our presently used edible fats digest without difficulty. In excess they also tend to induce high serum cholesterol values, but, in a practical sense, we do not yet have a clear quantitative record of where either the safety or optimum margins are in terms of human health. If further evidence indicates an advantage to be gained from changed intakes of linoleic or other acid, the problem will not be very difficult to solve.

A reasonable content of fat in the diet constitutes an important means of adjusting the appetite to a normal schedule of eating. Extreme practices in avoiding fats increase the risk of getting into poor eating habits and the risk of lowered efficiency between meals.

### Notable Progress Anticipated

Among recent research developments of major importance has been the report by W. S. Hartroft and his associates at Washington University, St. Louis. This group has developed a research technique with experimental animals that induces a high percentage of actual heart attacks subsequent to a marked rise in serum-cholesterol concentration and other cardiovascular lesions typical of the changes observed in human tissues. This technique should furnish an experimental procedure by which to accelerate research on quantitative aspects of the problem, as cited earlier. If the procedure can be adapted satisfactorily to experimentation with primates and other animals, it should be possible to study more rapidly and more incisively than in the past both the onset and the reversibility of cardiovascular lesions, including atherosclerosis and abnormal clotting.

One of the baffling problems in dealing with the health aspects of fats in nutrition has been the lack of adequate techniques to measure favorable or unfavorable trends with respect to the body changes that are associated with later breaks in health, such as heart attacks, cerebral hemorrhages, or diabetes. The use of radioactive carbon and hydrogen for labeling important nutrients and intermediates will now permit chemists to follow accurately a series of metabolic pathways simultaneously. The new precision tools for accurate analysis furnished by both paper and gas chromatography also open new horizons in biological research on fats.

Hence one is justified in being optimistic about the prospect of making substantial advances in this area of nutrition study and practice during the years immediately ahead. This confidence is also an important factor in my feeling of gratefulness that the food industry has taken an active and substantial interest in supporting research and personnel training to work vigorously toward the solution of problems that confront the public, the medical profession, and the food industry.

I am confident that the food industry will adapt the selection of raw materials and their manufacturing processes to give consumers maximum protection of public health insofar as these problems are related to nutrition. They will do it promptly in proportion to the availability of factual information to serve as a guide.

### Nation-wide Organizations

In varying degree many national and local organizations are at work on different aspects of heart disease and related problems. The National Institutes of Health have by far the largest programs of investigation and fund-granting activities in the entire field. Related work is also supported by the United States Department of Agriculture, the American Heart Association, and the Life Insurance Medical Research Fund.

The Nutrition Foundation, supported by the food and related industries, supports basic research that has proved of distinct value in relation to understanding both normal and abnormal fat metabolism and the related risks to health. This field of basic study on fat metabolism has grown so rapidly in interest that this year the member companies have voluntarily contributed additional funds beyond their regular membership payments so that basic advances might be made more rapidly. Our support of research on fat metabolism will be approximately $400,000 in 1957.

In our organization we have a Scientific Advisory Committee of 15 members selected chiefly from leading universities representing the medical and basic sciences. This group serves both as a planning and as a referee body in placing grants in support of research, subject to approval by the Board of Trustees. Another major part of our organization is the Food Industries Advisory Committee composed of key research personnel in the food and related industries who serve as liaison with member companies in all segments of the industry. We try to pinpoint our grants to develop the kind of research that will have greatest value, entirely in the public interest, without bias with respect to any one type of commodity. In addition to supporting basic research, the funds are directed chiefly to support advanced professional training of young scientists in the strongest medical and graduate schools.

We cooperate closely with other fund-granting agencies to avoid wasteful duplication and to fill in the most critical gaps where research is apparently most needed. In view of the obvious need for basic information to unravel specific problems in fat metabolism, both in industry and among academic scientists, special steps are being taken to accomplish effective cooperation.

One very practical point that is often overlooked in terms of market volume for the food industry is based on the fact that each person protected in full

health through an additional year represents a market for about one ton of food.

There can be no doubt of the economic and civic importance of research in this field of nutrition when we recognize that eight of the 10 leading causes of death in the United States today are associated with the metabolic and chronic diseases that are not primarily a result of infections. This situation brings the fruits of research progress into practically every home and every group in our society.

REFERENCE
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# The Influence of Dietary Fats on Serum-Lipide Levels in Man[1]

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THE RÔLE of unsaturated fatty acids in human nutrition is a topic of rapidly increasing popularity in both scientific and lay publications. It has been claimed that ingestion of this group of fatty acids decreases the concentration of lipides in the serum and that an inadequate intake of these acids may be the cause of the high serum-lipide levels so prevalent in Western civilization. Since these high levels are allegedly involved in the pathogenesis of arteriosclerosis and coronary disease, it has been tempting to implicate lowered intakes of unsaturated fatty acids in the rising incidence of these diseases. Although existing experimental data do not as yet warrant such conclusions, there is mounting evidence that the precise chemical composition of ingested fatty acids, in particular the degree of saturation, may have considerable significance in both health and disease (14).

E. H. Ahrens Jr.

The most recent stimulus to study in this field comes from clinical investigations which suggest that levels of serum-lipides may be related to the dietary intake of unsaturated fatty acids. Kinsell and Michaels (11) found that the feeding of coconut oil (a highly saturated fat) produced higher levels than the feeding of a highly unsaturated oil, soybean oil. Long-term feeding tests in this laboratory (4) indicated that serum levels of cholesterol and phospholipides varied inversely with the iodine number of six different dietary fats. The findings of these two laboratories were greatly extended in the detailed report by Bronte-Stewart *et al.* (8) and also were confirmed by the experiments of Beveridge *et al.* (5).

None of the experiments known to us has proven conclusively that the effect on serum-lipides of these dietary fats is due to the double-bond structure of their fatty acids. Nevertheless there has been widespread acceptance of this hypothesis by workers in human nutrition, and broad applications of the hypothesis have already been made. Since we think these extensions premature, it seems appropriate for us to set forth in some detail the studies carried out by us over the past three years which bear upon the important questions at issue. The unique design of these studies was based on the belief that nutritional experiments can be carried out as precisely in man as in animals. In view of numerous well-known differences in species response to nutritional variation, such an approach seemed essential. All recognized extra-dietary factors influencing serum-lipide levels were kept to a minimum. Patients were carefully selected and then observed within the closely supervised environment of the metabolic ward for periods long enough to assure establishment of equilibrium states. Dietary intakes were simplified and rigidly standardized; even the variable of cooking was eliminated. Yet all known requirements for essential foodstuffs, minerals, and vitamins were generously supplied. Medical and hospital care was provided to the patients without charge, and constant attention was paid to socio-economic factors which might disrupt their adjustment to the study situation. Under these circumstances the data obtained have quantitative as well as qualitative usefulness.

## Methods of Present Studies

A technique of oral feeding of liquid formulas was developed (3) and has been used almost exclusively in all feeding experiments since 1953. With this method patients were maintained at constant body weight by suitable adjustments of caloric intake; the proportions of foodstuffs remained unchanged. Changes in body weight rarely exceeded 1 kg. The basic formula consisted of protein 15%, fat 40%, and carbohydrate 45% of total calories. There was no source of calories other than the formula. Formula feeding has been used uninterruptedly for 36 months in one patient without recognized ill effect; however in most of the experiments discussed below the feeding tests lasted four to six months. Thirty-eight of 40 patients were observed continuously under strict metabolic-ward conditions; four of the 40 were sufficiently motivated and intelligent to follow the regimen at home. Iodized salt (2 g. sodium chloride with 200 μg. potassium iodide),[4] two multi-vitamin capsules, and ferrous gluconate (0.3 g.) were given

[1] This condensation of a paper appearing in The Lancet, *1*, 943–953 (May 11, 1957), was prepared by F. G. Dollear.
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[4] We are indebted to Clayton Rich, Rockefeller Institute Hospital, for demonstrating a requirement for supplemental iodine in our patients maintained solely by oral formula feeding. Unpublished serial radioactive iodine studies showed significant increases in uptake in some patients in less than one month.