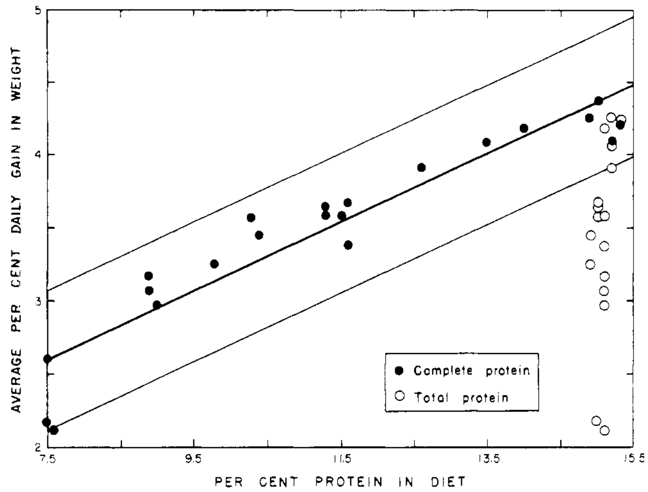

Figure 1. Correlation of average daily weight gain with complete and total protein

Fine lines represent range within which 95% of values may be expected to fall

there is a lack of correlation between the total protein in the diet and the growth response.

The results described in this paper demonstrate again that the nutritive value of foods is not adequately expressed by their total protein content (N × a factor) and that a better, although certainly not perfect, method would be the evaluation of foods on the basis of their complete protein content. This method of protein evaluation is not something for the distant future, but can be used with reasonable confidence at present. The amino acid composition of the important food proteins (*6, 8, 10*) and the amino acid pattern of complete protein (*2, 4*) are already known with sufficient accuracy to be used in many practical applications. One further point is that the amino acids in the food which are being evaluated must be available to the organism. If one or more essential amino acids have been rendered partly unavailable, because of underheating in the case of many legumes or by overheating (toasting) in the case of certain cereals, the amount of this loss must be taken into account and the quantity of complete protein must be corrected accordingly.

The concept of complete protein is also useful in another respect. For example, certain methods of processing milk result in the biological loss of approximately 10% of its lysine (*9*). This would be of importance when the milk proteins are employed to supply lysine to lysine-deficient diets. However, in diets in which lysine is present in relative abundance but total protein is limiting, the inactivation of 10% or so of the lysine is immaterial. Milk proteins are approximately 80% complete, as they contain 4 grams of cystine plus methionine per 16 grams of nitrogen and the assumed requirement is 5 grams. As milk contains 8.0 grams of lysine per 16 grams of nitrogen (requirement is 5.3 grams), almost one half of the lysine in milk could be lost during processing without diminishing the amount of complete protein. Such an extensive loss of lysine is never caused by modern methods of processing milk.

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REVIEW OF FILLED MILK

Nutritional Evaluation of the Replacement of the Fat in Whole Cow's Milk by Coconut Oil

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There is growing concern among nutritionists and others regarding the far-reaching implications of the use of additives and substitutes in industrially prepared foods. In various milk-deficit areas of the world coconut oil mixed with nonfat milk solids is offered as a replacement for whole milk, for all purposes, including the feeding of infants.

It is desirable to know to what extent nutritional intakes are jeopardized by this substitution, especially in the feeding of children who in some regions, may be already on suboptimal diets. The purpose of this study is to review the findings and facts that bear directly or indirectly on the comparative nutritional qualities of milk fat and coconut oil, and the implications of the substitution of the one for the other in whole cow's milk.

Fats other than coconut oil do not appear to be extensively used as a substitute for milk fat in the production of filled milks, except in the United States. Coconut oil is the cheapest of the usable oils in most tropical countries. WHO reports that some olive oil is used in Spain and peanut oil in El Salvador. Hydrogenated cottonseed oil appears to be the substitute fat generally employed in the United States.

The fat of cow's milk in the light of modern nutritional knowledge is significantly preferable to coconut oil. The latter is low in unsaturated fatty acids, including linoleic acid, high in saturated fatty acids, and especially high in lauric acid, compounds of which have a toxic effect when fed under certain conditions. Milk fat carries with it important milk nutrients, not present in skim milk or coconut oil. Cow's milk fat more closely approaches human milk fat in composition. Feeding experiments with animals and man have demonstrated two special conditions under which milk fat rates higher nutritionally than coconut oil—during the growth period and when the diet otherwise is marginal. Full-cream cow's milk is significantly preferable to a substitute, the fat content of which is coconut oil, for consumption by the young in areas where dietaries are not all they should be.

Chemical Composition of Fats

Chemically, milk fat bears no resemblance to coconut oil, which in its turn does not resemble any other fats or vegetable oils. Table I illustrates differences that are important from the nutritional point of view.

Coconut oil is lowest with respect to the essential fatty acid, linoleic acid. It is low in unsaturated fatty acid content and very high in saturated. It is astonishingly high in lauric acid; no other commonly consumed fat compares in this respect.

Coconut oil differs greatly from the class of fats often referred to as vegetable oils. Corn oil is listed in the table for comparison. When the term "vegetable oils" is used in contradistinction to "animal fats," coconut oil should be marked as an exception to either class. An excellent example illustrating the different dietary behavior of coconut oil and corn oil was described by Ahrens *et al.* (*1*). Blood cholesterol in a 27-year-old male increased sharply when 40% coconut oil was included in the diet. When coconut oil was replaced with corn oil, the cholesterol level dropped just as rapidly.

Cow's milk fat contains butyric acid, the glyceride of which is readily absorbed and metabolized, as has been demonstrated in the feeding of prematures (*35*). Coconut oil contains none.

Oleic acid, though not essential, makes a material contribution to a good diet. Its nutritional role has not been fully defined. Cow's milk fat contains a normal amount of this constituent, whereas coconut oil is one of the edible fats lowest in this respect.

Table I. Fatty Acids in Certain Food Fats (40)

Fatty Acids	Percentage of Total Fatty Acids: Cow's milk fat[a]	Human milk fat	Coconut oil[b]	Corn oil[c]
Linoleic (essential)	3.0	7.8	0.8	54.1
Oleic	35.0	36.5	4.0	30.0
Total unsaturated	41.2	51.8	4.8	87.6
Total saturated	58.8	48.2	95.3	12.4
Butyric, C_4	3.2	0.4	...	...
Caproic, C_6	1.8	0.1	0.4	...
Caprylic, C_8	0.8	0.3	6.5	...
Capric, C_{10}	1.4	2.2	9.0	...
Lauric, C_{12}	3.8	5.5	55.1	...
Myristic, C_{14}	8.3	8.5	16.9	0.1

[a] U. S. ("selected value"). [b] Philippine origin. [c] Commercial, refined.

Fatty Acids

Linoleic acid has been shown to be essential for maintaining good nutritional status. The needed supply can come only from food. Among other essential fatty acid–deficiency symptoms are skin disorders, especially in the growing young. The level of cholesterol in the blood is observed to rise when there is a deficiency of essential fatty acid. The majority of researchers in this field contend that among the causative factors in cardiovascular disorder are conditions which permit high levels of cholesterol in the blood.

Fats extremely high in saturated fatty acids, such as coconut oil, have been found to be a factor in increasing the cholesterol content of the blood, in part by reducing the effectiveness of linoleic acid (*11*).

The development of fatty livers has been used by investigators as an indication of an inadequate diet. It has been concluded by Stetten and Salcedo in feeding choline-deficient diets that intake of saturated fat proportionately increases fatty infiltration of the liver (*36*).

A well balanced fat should be neither high in saturated fats nor low in total unsaturated fatty acids (*18*). The ratio of saturated to unsaturated fatty acids in coconut oil as compared with milk fat is extremely wide (Table I).

Cow's milk fat does not average as high as human milk fat in essential fatty acid content, yet from clinical observations it must be concluded to be a satisfactory carrier of these nutrients in the infant's diet. Any fat that contains a lesser amount or causes an increased need for essential fatty acid is inadvisable as a substitute for milk fat. With respect to human milk fat, however, it has been demonstrated that the linoleic acid content may vary radically depending on the dietary intake of the mother, in some cases down to less than half of the cow's milk fat average (*19, 20*).

Short-Chain Fatty Acid Content

Studies show that fats composed of fatty acids in the short-chain class are readily digested, absorbed, and transported. The passage is direct from the intestine through the portal circulation rather than the lacteal (*7, 27*).

While both milk fat and coconut oil are higher in short-chain fatty acids than most edible fats, they differ when it comes to the individual acids. Milk fat is higher in the C_4 and C_6 fatty acids, and the reverse is true in the C_8 and C_{10} range.

Lauric Acid. The depot fat of man on a normal diet contains about 0.1% of lauric acid (*17*). The content of this fatty acid, expressed as percentage of total fatty acids in cow's milk fat, averages 3.8%, rising to an average of 5.5% in human milk fat. The extremely high figure of 55.1% for coconut oil is approached in no other edible fat.

A number of research studies have indicated that lauric acid and its compounds have a deleterious effect when fed in large amounts, particularly where the diet is suboptimal.

Cox (*8*), in feeding young rats with individual saturated fatty acid esters, observed a peculiarly high mortality rate among those receiving ethyl laurate. Similar results in feeding rats and other animals with various lauric acid esters, including the glyceryl ester, were later reported by Strach, Loeschke, and Blum (*37*), Stetten and Salcedo (*36*), Kesten, Salcedo, and Stetten (*24*), Keane, Cohn, and Johnson (*22*), Schön *et al.* (*34*), and Dryden, Gleis, and Hartman (*12*).

In all cases the toxic action of the lauric acid compounds was particularly marked where the diets were suboptimal nutritionally and where the test animals were in the early growing period.

Feeding Experiments with Commercial Filled Milk

Only a few studies have been reported wherein coconut oil–containing "filled milks" purchased on the market have been compared with competitive whole milk products.

Freeman and Ivy (*13*) compared a commercial filled milk with evaporated milk in feeding rats. Differences between the feeding regimens began to appear at 49 days; the filled milk group showed diminished growth and a greater incidence of loose stools.

Boutwell *et al.* (*6*) in their studies on the comparative nutritional value of milk fat and other fats and oils, including coconut oil, were led to the conclusion that filled milks are inferior to whole milk in growth-promoting properties when fed to young rats.

Coconut oil–filled concentrated milks, as sold commercially, differ from the milks they are designed to imitate also in composition. Imitation evaporated milk is generally standardized at 6% coconut fat as against 7.9 to 8.0% milk fat in evaporated milk. The nonfat portion of the filled milk, however, is often higher than that of evaporated milk.

Coconut Oil in Laboratory Diets

There are a number of reports of synthetic rations in which milk fat was incorporated on the one hand and various other fats on the other, including coconut oil. In a recent publication from the Yale Nutrition Laboratory, Barboriak *et al.* (*3*) observed 600 rats for periods up to 2 years on high-fat diets which included cow's milk fat and coconut oil. After several months of high-fat feeding, 61.6 or 81% of the calories, more fat storage was observed in the milk fat–fed rats than in those on diets containing coconut oil. It was concluded that milk fat is better digested and metabolized. The investigators found that coconut oil had the lowest growth-promoting value of the tested fats.

Numerous other reports in the literature demonstrate under various feeding conditions that coconut oil does not support the growth and well-being of young animals as well as other fats (*4, 14, 16, 33, 39*).

An especially important study from the practical point of view was recently published by Kehar and associates from India (*23*). Here, ghee (highly heated milk fat in practically anhydrous form) was made a part of a diet given to rats over a three-generation period. Coconut oil was one of the other fats fed for comparison. One of several rations used in the experiment was designed to represent the kind of suboptimal diet often consumed in India. Under such feeding conditions the ghee-fed animals grew better than those on diets containing coconut oil or the other fats. No significant differences were observed among the fats, however, when the animals were on a liberal diet.

In an earlier study in India, De and Karkun (*9*) fed to three human subjects rice-fish diets with various fats. Negative calcium balances were exhibited when coconut oil was the fat used, while milk fat maintained the subjects in positive calcium balance. The investigators also compared milk fat and coconut oil in feeding similar diets to rats. Growth rates were observed to be greater on the rations containing milk fat.

In Japan, Tange (*38*) found that the growth of rats fed butter was superior to the growth of those receiving coconut oil. However, when 2% yeast was added to the ration the differences were insignificant.

The coefficients of digestibility of cow's milk fat and coconut oil are similar —both over 97%. Absorption rates differ markedly, particularly in the earlier stages of digestion. Deuel (*10*) reports that in rat feeding fat absorbed in 4 hours was 71% for milk fat and 47.4% for coconut oil. Fat absorbed in 1 hour per 100 sq. cm. of surface was calculated to be 62.3 mg. for milk fat and 41.2 mg. for coconut oil.

Dietary Interrelationships

Dietary interrelationships constitute an area in nutrition that has had much attention. The particular superiority of cow's milk fat over other fats in promoting growth when the carbohydrate of the ration is lactose has been demonstrated by Boutwell and associates (*6*).

Nutrient relationships need more investigation; it may be found that the utilization of other important dietary elements is partially aided by the normal fat of the milk, a situation that does not obtain when other food fats are substituted (*2, 41*).

An extraordinary interrelationship in feeding 10% hydrogenated coconut oil along with 20% palmitic acid and 1% cholesterol to weanling mice was observed by Bosshardt, Kryvokulsky, and Howe (*5*). Complete cessation of growth occurred when the combination was fed; but the exclusion of any one of the three alleviated the adverse growth effect. Trace amounts of oleic and linoleic acids in the mixture as contributed by the coconut oil were believed to be a causative factor.

Milk Fat Nutrients Not Present in Coconut Oil

Milk may well be expected to contain factors that contribute to its nutritional value, other than protein, carbohydrate, minerals, vitamins, and fat, and are not to be found in the plant fats in identical form. Cow's milk fat is especially rich in them. Many have been isolated and studied, but much of the fraction remains unidentified (*21*).

Lecithin is present in cow's milk in substantial quantities—average 0.057 gram per 100 ml.; in human milk 0.078 gram per 100 ml. (*26*). On separation of cream from the nonfat portion of the milk, the lecithin accompanies the fat predominantly. Butter averages about 0.2% lecithin.

Dietary lecithin aids fat digestion and absorption. The oral administration of lecithin has been shown to reduce the level of blood cholesterol in hypercholesterolemic patients (*28*).

Some plants contain lecithin-like compounds, as in the case of soybeans (*17*). The presence of such substances in coconut oil has not been reported.

Other Phospholipides are contained in milk. Like lecithin they are mostly fat-soluble and pass into the cream on separation.

McGillivray finds evidence for the conclusion that the phospholipide content of dairy products is responsible for their greater effect on blood coagulation relative to vegetable fats (*25*). The feeding of cream stimulates the release of heparin into the blood stream, with resulting lipemia clearing (*30*). The evidence would seem to indicate, however, that the relationship among fat feeding, coagulation, and atherosclerosis should be investigated more extensively (*32*).

Plant Sterols, such as the sitosterols, contained in many vegetable oils, when present in the diet, have been credited by some investigators with having a favorable influence in holding blood cholesterol to lower levels, either by retarding absorption of dietary cholesterol or by exerting their influence metabolically. The general conclusion, however, is that these substances may be expected to have no more than minimal effect (*7, 31*). Whatever benefit there may be, it has not been demonstrated that coconut oil is a carrier of the sitosterols.

Cholesterol is present in cow's milk, though to a lesser extent than in human milk—0.014 and 0.020 gram per 100 ml., respectively (*26*).

Because all animal fats contain some cholesterol whereas vegetable fats do not, it has often been postulated that animal fats, including milk fat, should be shunned in favor of vegetable oils. The National Research Council Committee on Fats in Human Nutrition, however, concludes that in man dietary cholesterol has but minor influence on plasma cholesterol levels (*7*).

Trace Substances in milk fat, hitherto not recognized, are being identified by the newly perfected methods now available to the laboratories. For example, Hansen, Shorland, and Cooke have identified fatty acids in the range of C_{20} to C_{26} which are believed to result from the direct assimilation of dietary lipides by the cow (*15*).

Conclusions

Despite innumerable studies comparing the nutritional value of fats, there are many unanswered questions. For instance, with certain dietary regimens while milk fat induces a more rapid growth than most fats in young animals, longevity sometimes is significantly reduced (*29*). In practical infant nutrition, however, a parallel manifestation would seem unlikely. Current pediatric literature emphasizes the importance of providing the infant and child with a favorable nutritional environment as an essential condition for optimal health in later decades.

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BEEF AROMA

Some Volatile Constituents of Cooked Beef

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This study was undertaken to identify as many as possible of the volatile compounds responsible for the characteristic odor of cooked beef. While it is a common observation that this aroma develops only after heating, the literature affords relatively little information as to the nature of the compounds responsible.

Experimental Procedures and Results

Beef Broth. Fresh lean beef (round steak, U. S. Choice or U. S. Good) was trimmed free of fat, passed through a meat grinder, and refluxed with an equal weight of water for 3 hours. Two drops of Dow-Corning antifoam A were added before refluxing to prevent excessive foaming. After cooling and filtering, the broth was distilled to one third to one half of the original volume at atmospheric pressure either at its natural pH of 5 to 6 or after pH adjustment. Most of the characteristic odor was present in the distillate. Unless otherwise specified, only the distillate was used for chemical studies.

Basic Fraction. When the broth was to be examined for volatile basic compounds the distillate was collected in 2*N* acid, either sulfuric or hydrochloric, or the distillate was allowed to pass directly into a 2.6 × 28 cm. Dowex 50 (H^+) column and the column was subsequently eluted with 1*N* hydrochloric acid. The acidic solution obtained by either of these