Fats and Oils as Food for Man and Microorganisms

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EDIBLE oils and fats play a very important role in our diet. Fats represent the most concentrated form of fuel for the production of body energy. More of fatty foods could be utilized to an advantage by many people since most people do not use more than one hundred grams of fats daily. The eating of slightly less than three-fourths of a pound of fat would result in furnishing the average person with enough energy to go about his duties for a day. Naturally no one can long subsist on a strict fat diet but a meal devoid of fats and fat containing foods has no "staying qualities."

If one eats a heavy meal consisting of fat-free foods he feels hungry again within a short time. A feeling of satisfaction usually results from a meal of protein and carbohydrate foods with an adequate amount of oils and fats present. This phenomenon is due to the fact that fats stay in the stomach longer than proteins and carbohydrates and retard the digestion of these foods.

Ingested fat undergoes hydrolysis through the agency of lipase (fat-splitting enzyme) secreted by the pancreas and the whole process is powerfully aided by the bile salts dispersing the oil droplets and giving rise to emulsions.[1] We have found that the electrical charge (P.D.) on each globule is greatly increased by the bile salts and thus lipase adheres more readily to its oil substrate. Hydrolysis of the glycerides is accomplished by the enzyme; soaps (pancreatic juice furnishing alkalis) are formed along with glycerol and these water soluble substances are then taken into the body. As soon as the soaps enter the epithelial cells of the intestine, they are reconverted into neutral glycerides. Both glycerol and fatty acid need not be available at the same time in the cell, since the body can provide glycerol. Hence, fatty acids can serve as food. Glycerol alone can also serve as food, but there are certain theoretical dangers attending its prolonged use in large quantities.

Most of the edible oils and fats show complete absorption in the alimentary tract; the coefficients of digestibility being 96 to 100 per cent. It has been alleged and some data have been given to show that a high melting point fat, i.e., higher than mammalian temperatures, is not easily emulsified in the intestine and thus would have a lower digestibility coefficient. Drummond[2] has examined edible fats with melting points as high as 42°C. and has observed good utilization (90-94%).

WHEN the human body is considered as a heat engine and foods as fuel, we find the oils and fats heading all foods in energy value. Proteins have an energy value of 4.1 calories per gram, and carbohydrates (starches and sugar) the same energy value as protein. Oils and fats top the list at 9.3 calories per gram. The burning of ingested fat in the body spares the body proteins. Thus when a patient is considerably emaciated from wasting conditions such as typhoid fever, a high fat ("high calorie") diet is prescribed by the physician. In tuberculosis of the lungs, a high fat diet is often desirable. Fats are also useful medically in a variety of conditions, notably in epilepsy and certain types of gastric disturbances.

The theory once held to explain the nutritive value of oils and fats accounted for the value of cod-liver oil by assuming that the unsaturated fatty acids present were more readily oxidizable than an oil or fat with no double bonds. It is interesting in this connection to recall Ivanov's observations. He found that as one goes from the northern countries towards the tropics, there is a diminishing content of fatty acids with three double bonds in vegetable oils, and that the iodine number decreased with increase of temperature during growth.[3] Perhaps the body desaturates fatty acids before oxidation, but opinion is divided as to believing that unsaturated fatty acids are more readily utilizable than saturated fats and oils.

For many years, it was thought that the oils and fats functioned in the body only as sources

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of energy liberated by oxidation and the energy employed for maintenance of animal heat and for performance of work. Oils and fats were then valued in terms of calories after their digestibility had been determined. We are now aware that certain oils and fats contain properties or are carriers of principles that exert a profound effect on mental and physiological well-being.

Vitamins of Fats and Oils

IN 1907 Holst[4] described experimental studies of deficiency diseases. The subject of faulty diets had always interested seafaring peoples and it had long been common knowledge in Northern Europe that cod-livers and cod-liver oil were to be given in rickets. Johannesen[5] said that the people of Norway were so well acquainted with rickets that they never consulted a physician but treated it themselves with doses of cod-liver oil.

The lesson of fat starvation had to be learned over and over again before men began to compare notes. Explorers for a thousand years had experienced deficiency diseases. The condition of fat starvation was not made known to the world at large until 1888 when Nansen wrote his account of the first crossing of Greenland. The pemmican prepared for him was devoid of fat, and towards the end of his travels on the ice, he was in great distress. His hunger was not stayed by eating enormous quantities of the fat-free food and his distress was extreme. This condition was merely the first stage of another deficiency disease. Unfortunately, we saw all stages of food deficiency diseases in Central Europe during the war and after.

In 1913, Osborne and Mendel[6] observed a characteristic eye disease in their test animals deprived of fat in their diet. The simple addition of butter or cod-liver oil sufficed to cure or prevent the condition. Beef-fat possessed the property to a lesser extent, but lard or cottonseed oil were without effect. The principle was afterwards designated vitamin A—fat soluble.

Vitamin A (Fat Soluble): Test animals kept on a diet free from the vitamin known as "fat soluble A" may, after a time, develop the following conditions:

1—*Xerophthalmia or Ophthalmia.* (An abnormally dry condition of the eyeball; severe inflammation of the eyes, severe cases leading to atrophy and blindness. The lacrimal gland fails to function.

2—Inhibition of growth.

3—Increased susceptibility to bacterial invasion through weakened epithelial tissues.

(a) Abscesses at the base of tongue.

(b) Inflammation in ears and sinuses.

(c) Infections of lungs, skin and bladder.

4—Increased absorption of bacteria (of toxins?) through the intestinal wall. In these conditions bacteria pass through the mucosa into the body.[7]

5—Failure in ovulation.

Fortunately, the body can store vitamin A for future needs. However, vitamin A should be fed in sufficient amounts at all times. Feeding tests have shown increasing benefits throughout succeeding generations in the continued use of large quantities of vitamin A-containing foods.[8] The ingestion of rancid fats and oils may completely dissipate all of the stored vitamin A in the body. Oxidation destroys vitamin A. Oils and fats containing vitamin A are listed below according to their decreasing strength in this principle:

Cod-liver oil	++++	(highest activity).
Butter (summer)	+++	under 5% sufficient to prevent conditions listed above.
Fish liver oils	+++	
Whale oil	+++	
Cream	++	20% sufficient to prevent conditions.
Beef fat	++	
Palm oil	++	
Corn oil (yellow)	++	
Oleo oil	+	50% and more required in diet.
Oleo oil margarine	+	
Soy bean oil	+	
Cottonseed oil	±	present in small amounts.
Olive oil	±	
Coconut oil	±	
Peanut oil	±	
Vegetable oil margarine	—	usually absent.
Refined lard	—	
Hydrogenated oils	—	

We must now pass on to another group of conditions brought about by lack of vitamins found in fats and oils other than fat soluble A. (The water soluble vitamins B and C are not usually found in oils or fats.)

The Antirachitic Vitamin D: It was shown that butter rich in vitamin A tends to prevent xerophthalmia but has no effect on the calcium metabolism so that lime salts are not given to the developing bone. The investigations of Mellanby in England and McCollum and his coworkers in America demonstrated that cod-liver oil contained a vitamin distinct from A and this new antirachitic substance was designated vitamin D. Later it was shown that the favorable effects upon bone growth through exposure to sunlight or ultra-violet light were identical to the effects produced by vitamin D. When certain food materials containing ergosterol are subjected to ultra-violet irradiation, the ergosterol becomes a powerful antirachitic agent. This compound is found in the skin, hence the favorable action of sunlight or ultra-violet light may be due to the formation of vitamin D in the skin.

The following list of fats containing vitamin D are taken from Bills' paper[9]:

	Relative D Content
Puffer fish liver oil	1,500
Cod-liver	100
Shark liver	75
Catfish liver (Ohio R)	40
Seal blubber	Nil to 3
Whale blubber	Nil
Veal fat	Nil
Oleo oil	Nil
Coconut oil	Nil
Cottonseed oil	Nil
White corn oil	Nil
Olive oil	Nil
Peanut oil	Nil

Vitamin E (Fat Soluble): Vitamin E, the antisterility and reproductive principle, resembles A and D in some respects, but is absent from cod-liver oil and present in most vegetable oils. The oil of wheat germ is one of the richest sources of this vitamin. Vitamin E is present in animal fat and the body stores E to some extent.

It was mentioned before that the lack of vitamin A causes failure in ovulation, whereas in the absence of vitamin E, ovulation takes places but the placenta does not function properly and resorption of the embryo takes place.

The following animal and vegetable fats prevent these conditions: wheat germ oil, milk fat, cottonseed oil, hydrogenated cottonseed oil, leaf lard.

Most vegetable and seed oils contains the vitamin, but not in very high concentration. Coconut oil, olive oil, walnut oil, peanut oil, flaxseed oil, etc., are without effect except in large doses.

There are still other rôles played by oils and fats in nutrition. Burr and Burr[10] found that by excluding all fat from the diet of white rats a diseased condition of the tails resulted. This condition has often been noticed in colonies of white rats. The extremity of the tail becomes necrotic and curled. Then the tail sloughs off until only a stump remains before the condition becomes self limiting. The Burrs cured and prevented this condition in their test rats by adding 2% of unsaturated fatty acids to the basal ration. They further noticed that degeneration of the kidneys resulted during fat starvation, and a new type of sterility affected the rats. All of these conditions could be cured and prevented by the addition of 2% of unsaturated fatty acids to the diet. Saturated fatty acids were without effect. The addition of 5% of lard to the diet may act as a preventive of the conditions described by the Burrs.

It was also our experience to observe "ring tail" in rats in certain strains of our rat colonies. The tails of six sucklings in one litter of eight white rats showed the characteristic tail degeneration described by the Burrs. The diets were always rich in fat and unsaturated fatty acids (5% lard, 5% butter). The defective offspring were inbred for two generations and in each generation two "ring tail" defectives appeared in litters of eight and six, respectively. When a normal strain was introduced into the "ring tailed" stock, the progeny became free from stigmata and have continued so for six generations.

Microörganisms in Vegetable and Animal Fats

THE microbiology of butter is a subject too broad in scope to include in this talk. Aside from the dairy industry, microörganisms are never of much consequence in the oil and fat industries. Most oils and fats are not liable to microbiological deterioration like the putrefactive and fermentative processes in proteins and carbohydrates held under adverse conditions. Bacterial decomposition of oils and fats rarely takes place, and then only under exceptional circumstances. These conditions need never occur in any refinery. There are certain races of bacteria (non-pathogenic) which occasionally are found growing in vegetable or animal fats. These microörganisms elaborate a fat-splitting enzyme (lipase) often accompanied by an oxidizing enzyme. Microscopical examination reveals the bacteria as gram-positive, sporing rods. Respiration experiments prove these forms to be fixers of nitrogen.

Grossly mishandled shortenings of vegetable and of animal origin occasionally show discolorations. In case of pink discolorations the inciting agent may be either a pink torulae ("pink yeast") or one of several species of molds. A few species of bacteria have been found to discolor fats. These torulae, pink-producing molds and bacteria retain their pigment-forming characteristics even after prolonged cultivation on agar. That is to say, they soon appear colorless on agar but inoculated to any vegetable oil or fat they at once regain the power to elaborate pigment. All three types of these microörganisms hydrolyze all kinds of fats. One curious type of pink discoloration in fats is due to a nonchromogenic torula. This yeast when grown on agar produces a cream-colored colony and in nutrient broth no pigment is to be seen. However, when a trace of any soluble iron salt is added to the medium, a red color is produced. The iron content of most commercial oils and fats

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is large enough to produce pink discoloration provided the fat compound contains the colorless chromogen.

Discolorations ranging from greenish-blue to purple-blue have been observed in solid animal and vegetable fats. The microbiological process involved in producing the pigments is as follows: Certain yellow-producing cocci and some races of yellow-forming bacilli grow on solid fats at temperatures ranging from 39° F. to 99° F. The yellow pigment formed by these bacteria diffuses slowly into the fat. When the fat becomes rancid and peroxides appear, the pigment assumes a greenish color which in a few days deepens into blue. The original yellow pigment appears to be an oxidation-reduction indicator and can be oxidized with the usual reagents to a greenish-blue color and reduced back to the original yellowish pigment with reducing agents. Bacterial oxidases and peroxides will effect identical changes in the pigment.

Certain mineral oils such as machine oils can support the growth of oidia and other fungi provided moisture is present. These growths are often a nuisance in constant temperature oil baths. Bacteria may be found in machine oils but never grow well in this medium. Streptococci, staphylococci and B. pyocyaneus found contaminating machine cutting oils may give rise to skin infections if the oils are not treated with a disinfectant. Oils and fats exert a weak antimicrobic action and it is a common opinion amongst bacteriologists that certain oils are good preservatives. Hall and van Meter[11] observed that the preservation of peanut butter, for example, is due to the germicidal action of the peanut oil present. They did state, however, that they believed the organism died out because of the lack of available food.

Söhngen found a number of species of bacteria capable of oxidizing petroleum, paraffin oil and other hydrocarbons.[12] In garden soils, for instance, the number of paraffin oxidizing bacteria may reach 200,000 per gram of soil. Not a few species of bacteria show the power to elaborate lipase, likewise numerous species of molds, oidia, torulae and yeast hydrolyze and oxilize fats to a limited extent. Fortunately for the industry, only a few strict lipophilic microörganisms are present in nature.

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References

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Activated Carbon

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year, they had been having a great deal of trouble. The condensate from the steam seals of the turbines had to be thrown overboard because of the oil it had adsorbed. This fresh water had to be bought in port, and it was thought advisable to make some use of it. Passing of the condensate thru columns of granular carbon removed the oil and made the water fit for boiler feed, without fear of "priming" or lost efficiency.

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Circulating Rendering

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From the standpoint of the physical condition of the material and the problems involved in handling, edible materials are more easily rendered by this process than the inedible. Several tests have been made on edible materials with satisfactory results.

With the present experience there is no other possible conclusion than that the Circulating Rendering Process is universally applicable for rendering on a large scale. Its use will result in improved products and considerable simplification and economy in operation.

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