Dietary Fats: Dr. J. S. Pai

People enjoy the flavour of a rich, succulent tandoori chicken or onion pakoda or the creaminess of ice cream or chocolate as it melts in their mouth. There is a satisfied feeling after a snack of cheese on crispy cracker or silky smoothness of a dip with wafers. All these enjoyable experience is due to the fat they contain. Fats provide much of the great taste and texture due to which we crave for these foods. Fats play a vital role in their acceptability and when we indiscriminately change the amount or type of fats in these foods, we change the very features that make these foods appealing. Under today's focus of reduction of fats in our diets, we must not forget the important role fats play in foods. While developing reduced or low or even healthier fat foods, this aspect must always be considered while making any changes which are bound to affect the food appeal, otherwise we might end up with a product which may be healthier but totally unacceptable to consumers. Proper consideration of these aspects of fat and judicious changes can develop foods, which are healthy and also enjoyable.

Fatty acids are the building blocks of fats. Fats contain saturated, mono- and polyunsaturated fatty acids. Many foods naturally contain fats e.g. meats, fish, dairy products, nuts etc. Whole grains and vegetables contain only small amounts of fats when prepared without added fats. Except olives, coconuts and avocados, fruits virtually contain no fats. Many prepared or formulated foods contain fats. Whether a cake is prepared at home, from a mix or purchased, fats are one of the key ingredients. There are other fats like butter, margarine, shortening and oil we purchase as grocery staples.

Functions of Fats

They serve a variety of functions in foods. Their unique mouth-feel supplies rich, smooth, creamy sensation. They also absorb and blend ingredient flavours and aromas which is imparted to food uniformly. In cakes, they help produce a fine texture. They trap tiny air bubbles that help the batter to rise. Fats coat protein in flour making a tender or flaky product.

Butter, shortening, margarine and oil contain fat, but each has different properties affecting the properties of the products made using them. Not one fat can be used in all the applications and use of proper fat may be the key to acceptance to many foods.

Shortening works well with some baked goods. Since it has no water, when mixed with flour it does not produce gluten resulting in tender, flaky pie crusts and biscuits. Butter and margarine contain water and produce different texture, sometimes acceptable. Shortening also produces crispy French fries which when fried in oils have softer texture and are greasy.

Flavour of fats affect their application as well. Coconut oil is used for frying banana chips, whereas refined oil may be used for potato wafers. Some communities prefer mustard oil for frying most of their foods whereas most Indians prefer ghee for their traditional sweets.

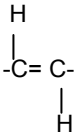
Some people use margarine products because they contain less saturated fat than butter and also they are cholesterol free and contain essential fatty acids. Lately however, partially hydrogenated fats used for many margarines are found to contain trans fatty acids, undesirable from nutrition point.

Solid fats and liquid oils

Fats differ because of the fatty acids they contain. All natural fats contain both saturated and unsaturated fatty acids. Fats with higher level of saturated fatty acids are firmer and more solid at room temperature and need more heat to melt. They perform better in certain applications like bakery products. Fats with higher level of unsaturated fats tend to be liquid at room temperature and are more useful in salad dressing etc. Another difference between saturated and unsaturated fats is the stability. Saturated fats are more stable to oxidative rancidity and unsaturated fats can easily undergo oxidation and form smaller odorous compounds giving rancidity to the fat and food containing it.

Saturated and unsaturated fatty acids have the difference in extent of hydrogen atoms in their molecules, saturated having more hydrogen atoms. Unsaturated fats can be hydrogenated to convert them into saturated, partially or fully. Most shortenings and margarines are made from liquid vegetable oils that have been partially hydrogenated, the extent of hydrogenation depending of the desired texture needed. Hydrogenation increases firmness and melting point of oils and fats. Partially hydrogenated fats still contain more unsaturated than saturated fatty acids.

They may also contain trans fatty acids, formed during hydrogenation process. These occur naturally in small amounts in animal fats and not in vegetable fats but during hydrogenation sizeable amounts are formed. Trans fatty acids are unsaturated but the hydrogen atoms of carbons involved in double bonds are on the opposite sides while in cis fatty acids they are on the same side.



Trans

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Trans fatty acid formation in hydrogenation process depends on process conditions including catalyst and pressure used etc. and determines the extent of trans fat in the final product. Trans fats have an advantage that they need less hydrogenation to achieve the increase in firmness so partially hydrogenated fats still contain more unsaturated than saturated fatty acids although they appear more solid. Since hydrogenation reduces the unsaturation, it makes the fat more stable towards oxidative rancidity.

Hydrogenation Process

Food scientists have been developing new products with fat profiles to meet process requirements as well as new nutrition recommendations. Hydrogenation process adds hydrogen atoms to points of unsaturation in fat molecules by reacting hydrogen gas with oil at high temperature and pressure in presence of a catalyst, making them saturated. The process is easily controlled and can be stopped at any desired point. If process is stopped after only a small amount of hydrogenation, oils have small amounts of trans fats. Further hydrogenation produces soft but solid appearing fats with greater trans fatty acid contents, which are used in solid shortenings and margarine. Fully hydrogenated oils are solid at room temperature, and since fatty acids essentially all become saturated, contain no trans fatty acids. Hydrogenation of oils rich in linoleic (di-unsaturated) and oleic (mono-unsaturated) acids may result in formation of oleic and stearic (fully saturated) acids.

Selection of fats for food applications

Consumers select fat-containing food products keeping in mind the taste, texture and appearance of foods as they were prepared at home. They do not want to sacrifice the sensory quality of food products and at the same time they would like them to be cost effective as well as nutritious. Manufacturers choose different products to balance flavour, texture, nutritional aspects and the cost. A manufacturer might make a biscuit, for example, using shortening because it produces the texture, flavour and freshness qualities consumers want. Olive oil might be added to a salad dressing to give it a certain flavour.

Table: Different applications and suitability of fats

BAKING	FRYING	DRESSINGS/SPREADS
Butter & Margarine (80% fat)		
Adds flavour; produces tender, crisp, chewy and brown cookies; tender pie crusts; cake frostings	Pan sautéing; burns easily	Suitable for spreading directly on foods
Margarine Spreads (20% - 60% fat)		
Cookies have "cake-like" texture; not suitable for pie crusts	May not be suitable	Suitable for spreading directly on foods
Nonfat/Very Low fat Spreads (0% - 10% fat)		
Not suitable	Not suitable	Suitable for spreading directly on foods
Salad/Cooking Oils		
For special recipes such as carrot cake, box cake mixes and quick breads	Pan sautéing; frying and deep-fat frying	Mix with vinegar or herbs/spices
Shortening		
Produces tender, light, moist texture; best for flaky pie crust; thick cake frostings	Pan sautéing; frying and deep-fat frying	May not be suitable
Sprays		
Pan coating	Can be used to sauté in non-stick pans, if watched carefully	Not suitable
Dressings/Spreads		
Special recipes; some box cake mixes	May not be suitable	Suitable for use directly on/in foods and in marinades

Food Science and Nutrition

Research in Fats & Oils, related to both health and functionality, have many practical applications for food scientists to study. Altering the fatty acid profile of fats and oils may be a starting point in research studies in Biotechnology. Studies are ongoing to increase stearic and oleic acid contents of oils for applications in soft margarine and confectionery fat applications. Even rearrangement of fatty acids within the triglyceride molecule can potentially alter the atherogenic potential of a fat and scientists are looking at this phenomenon also from the production of best dietary fatty acid profile for health promotion. Recommendations regarding the effects of dietary fats on health are continually evolving with new findings being published every year. Food science and technology for formulating food products consider these recommendations and are driven by consumer demands. It offers great opportunity to develop products promoting health based on these recommendations.

Nutritional Role of Dietary Fats

A balanced diet contains moderate amounts of fats. About 30% of calories may come from fats, of which less than ⅓ should come from saturated fat. To reduce fats, a variety of grains, fruits and vegetable may be consumed in good amounts. Lean meats, poultry and fish as well as low-fat dairy products help control fat intake in diets. Butter, oil and salad dressings should be curtailed in foods.

Although dietary fat make the foods more appealing from sensory perspective, it is essential for many nutritional functions in the body. They are vital to good health. Like carbohydrates and protein, fat is a source of energy. Fat is the most concentrated source of energy in the diet, providing 9 calories per gram compared with 4 calories from carbohydrates and protein. Fat is particularly important as energy source for infants and young children. More than half the calories in human milk come from fat.

Dietary fat also supplies essential fatty acids viz. linoleic and linolenic acids, which contribute to proper growth and human body can not synthesise them. Fat also maintains healthy skin, regulating cholesterol metabolism, and as precursor of prostaglandins regulate many body processes. They also carry and help absorb fat-soluble vitamins like A, D, E and K from the intestines. Since fats are digested slowly, they play a role in satiety or signals of fullness the body receives after eating.

Some fat is found in blood plasma and other body cells, but the largest amount is stored in body's adipose tissues, which not only store they as energy but also serve to insulate the body by supporting and cushioning organs.

Fats in the Diet: A Moderate Approach

Earlier guidelines recommended diets low in total fat to decrease the risk of heart disease, but the more recent research recommends consuming a moderate amount of dietary fat for overall good health, including heart health. 2005 Dietary Guidelines for Americans recommend 20 to 35% calories coming from fat for adults to meet the daily energy and nutritional needs while minimising risk of chronic disease. Most fats should come from sources of polyunsaturated and monounsaturated fats such as fish, nuts, and vegetable oils. Consuming less than 20% of calories from fats may decrease desirable high-density lipoprotein (HDL) cholesterol. Low intake levels also leads to inadequate intakes of vitamin E and essential fatty acids. Consuming more than 35% generally increases saturated fat intake and may also lead to consumption of excess calories. For children 2 to 3 years of age, fat intake recommended is 30 to 35% of calories whereas for those from 4 to 18 years, it should be 25 to 35% of calories from fat. Restricting fat intake is not recommended for infants less than 2 years of age as high energy intakes and essential fatty acids are required to support rapid growth and development. Dietary fat is mostly consumed through butter, margarine, vegetable oils, visible fat on meat and poultry, whole milk, egg yolk, nuts and bakery products.

Dietary Cholesterol

Cholesterol is a fat-like substance, which is vital to life and found in all cell membranes. It is also necessary for the production of bile acids and steroid hormones. The body produces about 800 to 1,500 mg cholesterol per day. Guidelines recommend that healthy people consume less than 300 mg per day. Cholesterol in diet comes from only animal foods like organ meats, egg yolk, meats and shellfish. Vegetable oils and shortening do not contain cholesterol. Diet is an important but just one of the many factors influencing blood cholesterol. Heredity could be a strong factor in some individuals, whose bodies produce excess amounts of serum cholesterol regardless of how little fat or cholesterol they consume. Risk factors beyond control are age, race and gender. However, there are many factors under control of individuals such as maintenance of healthy weight, getting adequate physical activity, controlling high blood pressure, avoiding cigarette smoking and managing stress. For those with diabetes, blood sugar level control is also important.

Blood cholesterol travels in their lipoprotein forms – lipid and protein combinations. There are 3 major classes: very-low-density lipoprotein (VLDL), low-density lipoprotein (LDL) and high-density lipoprotein (HDL). LDL is though to be associated with coronary heart disease, causing cholesterol deposits on arterial walls, hardening the arteries and leading to heart attack. In contrast, HDL is desirable, with more HDL is blood show lower risk of heart attack. It is thought to be involved in carrying cholesterol out of blood and back to liver for breakdown and excretion. Recommended blood levels of cholesterols are as follows: total cholesterol – less than 200 mg/dl; LDL cholesterol – less than 100 mg/dl and HDL cholesterol more than 40 mg/dl.

Fats and Obesity

Body weight is affected by a combination of genetic, metabolic, behavioural, environmental, cultural and socio-economic factors. Excess weight or obesity increases risk of many diseases and health problems including hypertension, diabetes, stroke, and certain cancers. For most individuals, excess weight is due to excessive caloric intake and/or inadequate physical activity. Dietary fats alone do not cause obesity but not more than 35% calories are recommended from fats to avoid excess energy intake. Although the proportion of fat in American diets has decreased, body weight has not declined. In European countries, diets contain more calories from fat but people are less obese than in US. Excess intake of any caloric component of food, i.e. protein, fat, carbohydrate or alcohol should be controlled.

Intervention studies indicate that significant reductions, more than 4% of calories from fats resulted in small losses in body weight. Another study compared high fat and high carbohydrate diet of equal calories and failed to show difference in weight gain in two. However, one study showed weight loss due to low calorie, low fat diet.

Effect of Dietary Fats on Cholesterol

Mono- and polyunsaturated fatty acids are present in unsaturated fats. When they replace saturated fats in the diet, they help reduce blood cholesterol levels and thus lower the risk of heart disease. Their sources are fish, nuts and vegetable oils. Canola, olive and nuts such as groundnuts are high in monounsaturated fats. Two polyunsaturated fatty acids namely alpha-linolenic acid (omega 3 fatty acid) and linoleic acid (omega 6 fatty acid) are essential fatty acids. They are essential for body function as they cannot be synthesised by body. They must be taken through foods. Their deficiency may produce symptoms like scaly skin and dermatitis. Two other omega 3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are found in fish like salmon, mackerel, tuna and trout, and shellfish.

Omega 3 fatty acids have been shown to be associated with cardio-protective effects. They may lower triglyceride levels and show lower artery blockage reducing the risk of abnormal thickening of arteries due to fatty deposits. Other benefits may be in health conditions like depression, cancer, lupus and asthma. To a limited extent, body can convert alpha-linolenic acid into EPA and DHA. Although alpha-linolenic acid has cardio-protective effect, evidence is stronger for EPA and DHA. Intake of 5 to 10% of calories from omega 6 fatty acids may reduce coronary heart disease risk and mortality.

Many studies have shown that high intakes of saturated fats can raise the level of total and low-density lipoprotein (LDL) cholesterols in blood and increase the risk of coronary heart disease. A reduction of 1% of calories from saturated fats decreases LDL cholesterol by about 1-2%. Guidelines recommend not more than 7-10% calories from saturated fat.

Although saturated fats are accepted to be responsible for high cholesterol levels, fats rich in stearic acid were found not to increase the levels very much, whereas myristic and palmitic acids were shown to be highly hypercholesterolemic. Several studies have shown that stearic acid has a minimal effect on LDL cholesterol and no effect on HDL cholesterol, while other long chain saturated fatty acids increase both LDL and HDL cholesterols.

Recent studies have also shown an association between breast cancer and dietary fats, with higher intake of saturated fats were shown to be significantly associated with breast cancer risk while unsaturated fats were not.

Trans Fatty Acids

Trans fatty acids are found naturally in animal fats. They are also formed in hydrogenation of oils which are used in cookies, crackers, pastries and fried foods. Evidence indicates that they may increase risk of heart disease by increasing both total and LDL cholesterols. Some studies also indicate that they may decrease HDL cholesterol. A 1999 study showed the mean trans fatty acid intake in the US is 2.6% of total calories. It is also estimated that 20-25% of trans fatty acids in the diet come from naturally occurring sources. However, in India it may be different and much higher percentage of trans fats may be consumed through hydrogenated fat which is not only consumed through bakery products but also through vanaspati used for cooking and frying food products in domestic and commercial preparations. Nutrition labelling in the US makes it mandatory to declare the trans fatty acid contents of foods, besides declaring the amount of saturated fats. USFDA also allows label claim of the potential of foods low in fat, saturated fats and cholesterol to reduce the risk of coronary heart disease

Some naturally occurring trans fatty acids are conjugated linoleic acid (CLA) and vaccenic acid, present in dairy products, and meat. CLA decreases fat deposition and body lipid content. Animal studies show CLA to protect against development and progression of atherosclerosis as well as exhibiting anti-carcinogenic effect.

Trans fats form when oil is partially hydrogenated, converting oils into more stable liquid or semi-solid form. There are some advantages of partially hydrogenated oils in that they produce food products that stay fresh longer and have a more desirable texture in such products like spreadable topping/margarine, flaky piecrusts, crispy cracker and firm non-greasy French fries. These products also resist rancidity compared to unhydrogenated oils. However, since there are adverse nutritional effects of trans fats there are efforts to avoid trans fats and to substitute it in above products by other fats low in or devoid of trans fats.

Trans fats can be reduced by lowering total fat or by substituting partially hydrogenated fat, not by saturated but by mono- and polyunsaturated fats. Most liquid vegetable oils such as soybean, corn, safflower, sunflower, groundnut oils are naturally lower in saturated fats and free of trans. Margarines are prepared which are lower or free of trans fat, but liquid or low fat margarines have limited applications.

It is a challenge to produce acceptable low or nil trans fat alternatives for partially hydrogenated fats, which are also lower in saturated fats. These fats must provide the same functional advantages such as texture, crispness, appearance and stability to product while remaining cost effective and abundant for use. There are four alternatives currently available.

Stable oils and fats: The most common oils that are relatively stable are palm, corn and cottonseed oils compared to highly unsaturated oils like soybean, safflower, sunflower oils. These contain no trans but they are liquid. Used to lesser extent are palm kernel, coconut, high oleic varieties of canola, safflower, sunflower etc., low linoleic soybean oils and animal fats like tallow and lard.
Interesterified Oils and fats: Interesterification process rearranges fatty acids in a mixture of oil and solid fat forming fat having desirable melting characteristics useful as shortening.
Modified partially hydrogenated oils: The process conditions such as time, pressure, temperature or catalyst used for hydrogenation process could be altered with significant reduction in trans fat content.

Fully hydrogenated: Complete hydrogenation avoids formation of trans fatty acids which require some unsaturation.

A new oil has captured the interest of nutritionist namely, rice bran oil. This was earlier considered a low grade oil because of its high free fatty acid content. However, improvements in milling practices and in refining process has produced an oil which is not only a well accepted oil but also very good from the health point of view. The presence of oryzanol and tocotrienol has beneficial effect on cholesterol in body.

Information sources: International Food Information Council Foundation; American Dietetic Association; Wikipedia; USDA Dietary Guidelines

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