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A REVIEW ON PURIFICATION AND CHEMICAL MODIFICATION OF OILS AND FATS

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ABSTRACT

Fats and oils are recognized as essential nutrients in both human and animal diets present in varying amounts in many foods. They provide the most concentrated source of energy of any foodstuff. Essential fatty acids are precursors for important hormones and prostaglandins. They are carriers for fat soluble vitamins, and serve to make foods more palatable. Fats keep cell membranes fluid and flexible. They promote normal growth, especially of blood vessels and nerves. The fats and oils keep the skin and other tissues youthful and supple through lubrication. So, if you are not consuming enough of the proper fats, you will not be able to make and balance hormones properly. Our bodies cannot live fat free. We need significant amounts of essential fatty acids to function properly, enhance immunity, beneficial in cardiac, cancer diseases. The knowledge of the chemical composition of fats and oils and their purification and chemical modification of oils and fats is essential for heath benefits.

Keywords: Oils, fats, purification, modification, Interesterification.

1. Introduction:

Fats and oils are chemically called "triglycerides" resulting from the combination of one unit of glycerol with three units of fatty acids. They are insoluble in water but soluble in most organic solvents. They have lower densities than water and at normal room temperatures range in consistency from liquids to solids. When solid appearing they are referred to as "fats" and when liquid they are called "oils." The term "lipids" embraces a variety of chemical substances. In addition to triglycerides, it also includes mono- and diglycerides, phosphatides, cerebrosides, sterols, terpenes, fatty alcohols, fatty acids, fat-soluble vitamins, and other substances[1-3].

Fats and oils are commonly known as natural ingredients for health and other purposed. They provide the most concentrated source of energy to body. The oils are collected mainly through a process of mechanical pressing and solvent extraction method. They have a long tradition of providing a variety of therapeutic benefits and many of the traditionally known benefits have been confirmed through modern scientific research. It has been established that the use of oils in a cooking and has an antiseptic and antimicrobial action as well as healing and soothing effect on the skin. Oils help the skin and hair to detoxify, drain, heal and regenerate. They are carriers for fat soluble vitamins, and serve to make foods more palatable. Fats and oils are present in varying amounts in many foods. The principal sources of fat in the diet are meats, dairy products, poultry, fish, nuts, and vegetable fats and oils. Most vegetables and fruits consumed as such contain only small amounts of fat. Fats keep cell membranes fluid and flexible which in turn affects the white blood cells that repel invaders of the body (builds your immune system). They promote normal growth, especially of blood vessels and nerves. If you are not consuming enough of the proper fats, you will not be able to make and balance hormones properly. Our bodies cannot live fat free. We need significant amounts of essential fatty acids to function properly and enhance immunity[4-7].

2. General methods of oil extraction and expression:

Food fats and oils are derived from oilseed and animal sources. Animal fats are generally heat rendered from animal tissues to separate them from protein and other materials. Vegetable fats are obtained by the extraction (solvent or pre-press/solvent extraction methods) or the expression (cold or hot methods) of the oil from the oilseed source. Commonly used solvent in extraction are hexane and petroleum ether. The fats and oils obtained directly from the extraction of the oilseeds are termed "crude" fats and oils. Crude fats and oils contain varying but relatively small amounts of naturally occurring non-glyceride materials such as free fatty acids, water , protein, phosphatides etc. that are removed through a series of processing steps to produce the desired oil. However, that not all of the non glyceride materials are undesirable elements such as tocopherols, protecting the oils from oxidation and provide vitamin E. So, processing of purification is carried out in such a way as to control retention of these useful substances. Partial hydrogenation is employed frequently to improve the stability of fats and oils and to provide increased usefulness by imparting a semi-solid consistency to the fat for many food applications. The modern processing of edible fats and oils is the single factor most responsible for upgrading the quality of the fat and oil consumed in the diet today [4, 8].

3. Oil purification and modification methods

Crude fats and oils contain varying substances that may influence undesirable flavor, color, or keeping quality. These substances are removed through a series of processing steps. The purification processing can be divided into seven types: 1. Degumming, 2. Refining, 3. Bleaching, 4. Deodorization, 5. Fractionation, 6. Hydrogenation, and 7. Interesterification.

3.1. Degumming

Some oils such as soybean oil have a treatment known as degumming. The bulk of certain phosphatides such as lecithin are separated through this operation. Crude oils having relatively high levels of phosphatides may be degummed prior to refining to remove the majority of those phospholipid compounds. The process generally involves treating the crude oil with a limited amount of water to hydrate the phosphatides and make them separable by centrifugation. Soybean oil is the most common oil to be degummed; the phospholipids are often recovered and further processed to yield a variety of lecithin products [4, 8].

3.2. Refining

The process of refining reduces the free fatty acid, phospholipids, carbohydrates, or proteins in oils or fats. The most widely practiced form of refining (or "alkali refining") method is an alkali treatment. By treatment of the fats and oils with an alkali solution, the free fatty acid converts into water soluble soaps. Phospholipids, carbohydrates, proteins and mucilaginous substances also can be changed to water soluble substances with hydration. After the alkali treatment, the fats and oils are washed with water to remove residual water soluble soaps [4, 9].

3.3. Bleaching

The bleaching process is removing coloring materials, such as chlorophyll and carotene and purifying the fats and oils. The method is by adsorption of the color producing substances on an adsorbent material. Bentonite, silica gel and activated carbon are used as bleaching adsorbents[10]. Anhydrous silica gel and activated carbon also are used as bleaching adsorbents to a limited extent[4].

3.4. Deodorization

Deodorization is a vacuum steam distillation process for the purpose of removing undesirable flavors and odors, mostly arising from oxidation, in fats and oils. Normally this process is accomplished after refining and bleaching. The deodorization of fats and oils is simply a removal of the relatively volatile components from the fat or oil using steam11. This is feasible because of the great differences in volatility between the substances that give flavors and odors to fats and oils and the triglycerides. Deodorization is carried out under vacuum to facilitate the removal of the volatile substances, to avoid undue hydrolysis of the fat, and to make the most efficient use of the steam. Deodorization does not have any significant effect upon the fatty acid composition of most fats or oils. In the case of vegetable oils, sufficient tocopherols remain in the finished oils after deodorization to provide stability. The deodorization utilizes the differences in volatility between off-flavor and off-odor substances and the triglycerides[4].

3.5. Fractionation

Fractionation is the removal of solids by controlled crystallization and separation techniques involving the use of solvents or dry processing. There are three kinds of fractionation process such as crystallization, winterization, and pressing. Crystallization is the widespread technique. A mixture of triglycerides is separated into different melting points based on solubility at selected temperature. Next, a small quantity of material is crystallized to avoid hazes of liquid fractions at refrigeration temperatures, this process is called winterization. Many oils, including cottonseed and hydrogenated soybean oils, are winterized. Finally, pressing process is used to separate of liquid oil from solid fat. This process presses the liquid oil from the solid fraction by hydraulic pressure or vacuum filtration. This process is used commercially to produce hard butters and specialty fats from oils[10]. A similar process called dewaxing is utilized to clarify oils containing trace amounts of clouding constituents.

3.6. Hydrogenation

In hydrogenation, hydrogen is added directly to react with unsaturated (double bonds) oil in the presence of nickel catalyst. The need for the hydrogenation is based on (1) converting liquid oils to the semi-solid forms and (2) increasing the oxidation and thermal stability of fats and oils. This process greatly influences the desired stability and properties of many edible oil products. The hydrogenation process is easily controlled and can be stopped at any point. A gradual increase in the melting point of fat and oil is one of the advantages. If the double bonds are eliminated entirely with hydrogenation, the product is a hard brittle solid at room temperature. Shortening and margarine are typical examples[10, 12].

If the hydrogenation of cottonseed or soybean oil, for example, is stopped after only a small amount of hydrogenation has taken place, the oils remain liquid. These partially hydrogenated oils are typically used to produce institutional cooking oils, liquid shortenings and liquid margarines. Further hydrogenation can produce soft but solid appearing fats which still contain appreciable amounts of unsaturated fatty acids and are used in solid shortenings and margarines. When oils are more fully hydrogenated (saturation), this conversion also affects *trans* fatty acids eliminating them from fully hydrogenated fats. Both positional and geometric (*trans*) isomers are formed to some extent during hydrogenation, the amounts depending on the conditions employed. Biological hydrogenation of polyunsaturated fatty acids occurs in some animal organisms, particularly in ruminants[7,13].

3.7. Interesterification

Another process used by oil processors permits a rearrangement or a redistribution of the fatty acids on the glycerol fragment of the molecule. This process, referred to as interesterification, is accomplished by catalytic methods at relatively low temperature. Under some conditions the fatty acids are distributed in a more random manner than they were present originally. Other conditions permit the rearrangement process to direct the fatty acid distribution to an extent that allows further modification of shortening properties to be obtained. The rearrangement process does not change the degree of unsaturation or the isomeric state of the fatty acids as they transfer in their entirety from one position to another. Lard in its natural state possesses a very narrow temperature range over which it has good consistency for practical use in the kitchen. At slightly above normal room temperature, ordinary lard becomes somewhat softer than desirable, and at temperatures slightly lower, it becomes somewhat firmer than is desirable. Molecularly rearranged lard shortenings have a satisfactory consistency over a much wider temperature range[10,14,15].

3.8. Esterification

Fatty acids are the form of esters and consumed as such. Triglycerides are the example of esters, the predominant constituents of fats and oils. When fats or oils are consumed and digested, they hydrolyzed initially to diglycerides and monoglycerides which are also esters. These esters are finally hydrolyzed to glycerol and fatty acids. In the reverse process, esterification, an alcohol (glycerol) is reacted with an acid (fatty acid) to form an ester such as mono-, di-, and triglycerides. In an alternative esterification process, called alcoholysis, an alcohol (glycerol) is reacted with fat or oil to produce esters such as mono- and diglycerides. In these esterification processes, edible acids, fats, and oils can be reacted with edible alcohols to produce useful food ingredients that include many of the emulsifiers[4,14,15].

3.9. Emulsifiers

Many foods are consumed as emulsions, which are dispersions of two or more immiscible liquids such as water and oil, e.g., milk, ice cream, and sausage. Emulsifiers, provide emulsion stability, when lack of stability results in separation of the oil and water phases. Some emulsifiers also provide valuable functional attributes in addition to emulsification. These include aeration, starch and protein complexing, hydration, crystal modification, solubilization, and dispersion[4]. Some examples of emulsifiers and their characteristics are listed in Table 1.

3.10. Additives and Processing Aids

The Manufacturers maintenance the quality of oils and fats during the time of processing (storage, handling, and shipping of finished products) to time of consumption by adding low levels of approved food additives. When addition provides a technical effect in the end-use product, the material added is considered a direct additive. Such usage must comply with FDA regulations governing levels, mode of addition, and product labeling[4, 16]. Different additives and their uses in shown in table 2.

4. REACTIONS OF FATS AND OILS

4.1. Hydrolysis of Fats

Like esters, glycerides can be hydrolyzed readily or partially. Partial hydrolysis of triglycerides will yield mono- and diglycerides and fatty acids. When the hydrolysis is carried to completion with water in the presence of an acid catalyst, the mono-, di-, and triglycerides will hydrolyze to yield glycerol and fatty acids. With aqueous sodium hydroxide, glycerol and the sodium salts of the component fatty acids (soaps) are obtained. In the digestive tracts of humans, animals and bacteria, fats are hydrolyzed by enzyme lipases. Some edible oils are source of Lypolytic enzymes like palm fruit, coconut). These lipolytic enzymes present in crude fats and oils are deactivated by the temperatures used in oil processing, so enzymatic hydrolysis is unlikely in refined fats and oils[4].

4.2. Oxidation of Fats

2.2.1 Autoxidation*:* Oxidation induced by air at room temperature referred to as "autoxidation." This is a slow process which occurs only to a limited degree. In autoxidation, oxygen reacts with unsaturated fatty acids. Initially, peroxides are formed which in turn break down to hydrocarbons, ketones, aldehydes, and smaller amounts of epoxides and alcohols. Heavy metals present at low levels in fats and oils can promote autoxidation. Fats and oils often are treated with chelating agents like citric acid to inactivate heavy metals[4].

The result of the autoxidation of fats and oils causes objectionable flavors and odors known as "oxidative rancidity." Oxidative rancidity depends on the degree of unsaturation, the presence of antioxidants, and other factors. The presence of light, for example, increases the rate of oxidation. It has been found that oxidatively abused fats can complicate nutritional and biochemical studies in animals because they can affect food consumption and reduce the vitamin content of the food. Knowing the oxidative condition of unsaturated fats is extremely important in biochemical and nutritional studies with animals[4].

4.2.2. Oxidation at higher temperatures: The rate of oxidation is greatly accelerated at higher temperatures. The more unsaturated the fat or oil, the greater will be its susceptibility to oxidative rancidity. Predominantly unsaturated oils such as soybean, cottonseed, or corn oil are less stable than predominantly saturated oils such as coconut oil. Methylsilicone often is added to institutional frying fats and oils to reduce oxidation tendency and foaming at elevated temperatures. Frequently, partial hydrogenation is employed in the processing of liquid vegetable oil to increase the stability of the oil. Also oxidative stability has been increased in many of the oils developed through biotechnological engineering. The stability of a fat or oil may be predicted to some degree by the oxidative stability index[4].

4.3. Polymerization of Fats

All commonly used fats and particularly those high in polyunsaturated fatty acids tend to form some larger molecules known as polymers when heated under extreme conditions of temperature and time. Under normal processing and cooking conditions polymers are formed in insignificant quantities. Although the polymerization process is not understood completely, it is believed that polymers in fats and oils arise by formation of either carbon to carbon bonds or oxygen bridges between molecules. When an appreciable amount of polymer is present, there is a marked increase in viscosity. Animal studies have shown that any polymers that may be present in a fat or oil are absorbed poorly from the intestinal tract and are excreted as such in the feces[4].

4.4 Reactions during Heating and Cooking

Glycerides occur to chemical reactions (oxidation, polymerization, hydrolysis) particularly during deep fat frying. These reactions, reflected as a decrease in iodine value of the fat and an increase in free fatty acids, depends on the frying conditions, like temperature, aeration, and duration. The composition of a frying fat also may be affected by the kind of food being fried. In this manner the fatty acid composition of the frying fat will change as frying progresses. This replacement with fresh fat tends to dilute overall compositional changes of the fat during prolonged frying. Frying conditions do not, however, saturate the unsaturated fatty acids, although the ratio of saturated to unsaturated fatty acids will change due to some polymerization of unsaturated fatty acids.

It is the usual practice to discard frying fat when (I) prolonged frying causes excessive foaming of the hot fat, (II) the fat tends to smoke excessively, usually from prolonged frying with low fat turnover, or (III) an undesirable flavor or dark color develops. Any or all of these qualities associated with the fat can decrease the quality of the fried food [17,18].

5. DISCUSSION

Fats and oils are essential nutrients for both human and animal diets in varying amounts. Knowledge of the chemical composition of fats and oils and the sources from which they are obtained is essential in understanding nutrition and biochemistry. They promote cell membranes flexibility, immune system, normal growth, especially of blood vessels and nerves. They are source of energy and essential fatty acids which are precursors for some hormones and prostaglandins, carriers for lipid soluble vitamins, serve to make foods more palatable. The polyunsaturated fatty acids are beneficial in various disorders such as cardiac, cancer diseases and build immune system[16,19-24]. So, if you are not consuming enough of the proper fats, you will not be able to make and balance hormones properly. Our bodies cannot live without fat or lipid. We need significant amounts of essential fatty acids to function properly and enhance immunity. Special lipids referred to as "medium chain triglycerides" (MCT) containing C6 to C10 saturated fatty acids have been used in particular clinical applications. Certain modifications of MCTs are soluble in both oil and water systems and are metabolized more rapidly than conventional fats and oils[4]. Whereas conventional fats and oils are absorbed slowly and transported via the lymphatic system, MCTs are absorbed relatively quickly and transported via the portal system.

Because of their unique ability to pass through the intestinal epithelium directly into the portal system, MCTs have become the standard lipid used in the treatment of various fat malabsorption syndromes. In certain liquid formula diets and intravenous fluids, MCTs may be combined in varying proportions with corn oil, soybean oil, or safflower oil[16,19-24].

6. CONCLUSION

This review has a broad scope of the importance of dietary fats and oils as an essential nutrient and the usage of fats and oils in a variety of food products. Much research continues on the role of dietary fat in relation to health and needed to keep the information as current and useful as possible.

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