Food Chemistry I

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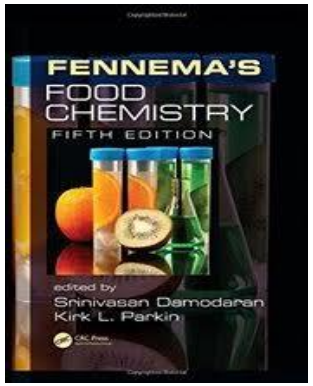
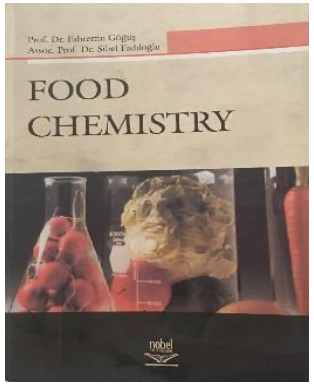
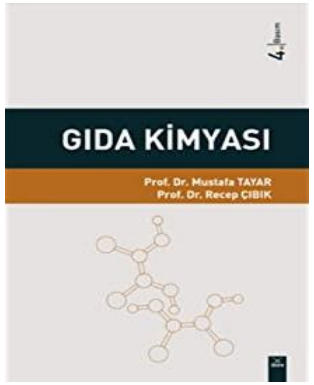
1. 

2. 

3. 

1. Fennema O.R., Ed: Damodaran S. and Parkin K.L. 2017. *Fennema's Food Chemistry*, CRC Press Taylor & Francis Group Boca Raton, FL, USA.
2. Göğüş F. and Fadıloğlu S. 2006. *Food Chemistry*, Nobel Akademik Yayıncılık, Ankara.
3. Tayar M. ve Çıbık R. 2013. *Gıda Kimyası*, Dora Basın-Yayın Dağıtım Ltd. Şti., Bursa.

CHEMICAL REACTIONS OF LIPIDS

1. Hydrolysis

2. Oxidation

3. Chemical Reactions in High Temperatures

Thermal Degradation

Thermal Polymerization

HYDROLYSIS REACTIONS

Lipids can be hydrolyzed by acid, alkali, heat, and enzymes to release free fatty acids in the presence of water. Triacylglycerols are firstly hydrolyzed to diacylglycerols, followed by monoacylglycerols and finally glycerol in sequence.

Lipid hydrolysis is not preferred in most cases. However, moderate lipid hydrolysis can create special flavors for some foods.

OXIDATIVE REACTIONS, CHEMICAL DETERIORATION OF LIPIDS (RANCIDITY)

The unsaturated bonds present in fats and oils represent active centers that, among other things, may react with oxygen. This reaction leads to the formation of primary, secondary, and tertiary oxidation products that may make the fat or fat-containing foods unsuitable for consumption. The process of autoxidation and the resulting deterioration in flavor of fats and fatty foods are often described by the term *rancidity*.

Among the many factors that affect the rate of oxidation are the following:

- amount of oxygen present
- degree of unsaturation of the lipids
- presence of antioxidants
- presence of prooxidants, especially copper, and some organic compounds such as heme-containing molecules and lipoxidase
- nature of packaging material
- light exposure
- temperature of storage

The autoxidation of lipids is a typical free radical chain reaction and the autoxidation rate is markedly inhibited by chemicals which can interfere with free radical reactions.

The pathway of lipid autoxidation has been simplified by dividing the reaction into three steps:

* Initiation
* Propagation
* Termination

* Initiation

In the initiation phase reactions prevail that form and expand the pool of radicals. $RH \rightarrow R\bullet + H\bullet$

* Propagation

During the propagation phase the chain reaction between fatty acid radicals and molecular oxygen leads to the formation and accumulation of the primary hydroperoxide products.

$$R\bullet + O_2 \rightarrow ROO\bullet$$

$$ROO\bullet + RH \rightarrow ROOH + R\bullet$$

* Termination

Reactions between radicals leading to non-radical products dominate during the termination phase.

$$R\bullet + R\bullet \rightarrow R\text{-}R$$

$$R\bullet + ROO\bullet \rightarrow R\text{-}O\text{-}O\text{-}R$$

$$ROO\bullet + ROO\bullet \rightarrow R\text{-}O\text{-}O\text{-}R + O_2$$

CHEMICAL REACTIONS IN HIGH TEMPERATURES

Lipids might undergo

* oxidation
* degradation
* polymerization
* condensation

* lower fatty acids
* hydroxyl acids
* esters
* aldehydes
* dimmers
* trimers

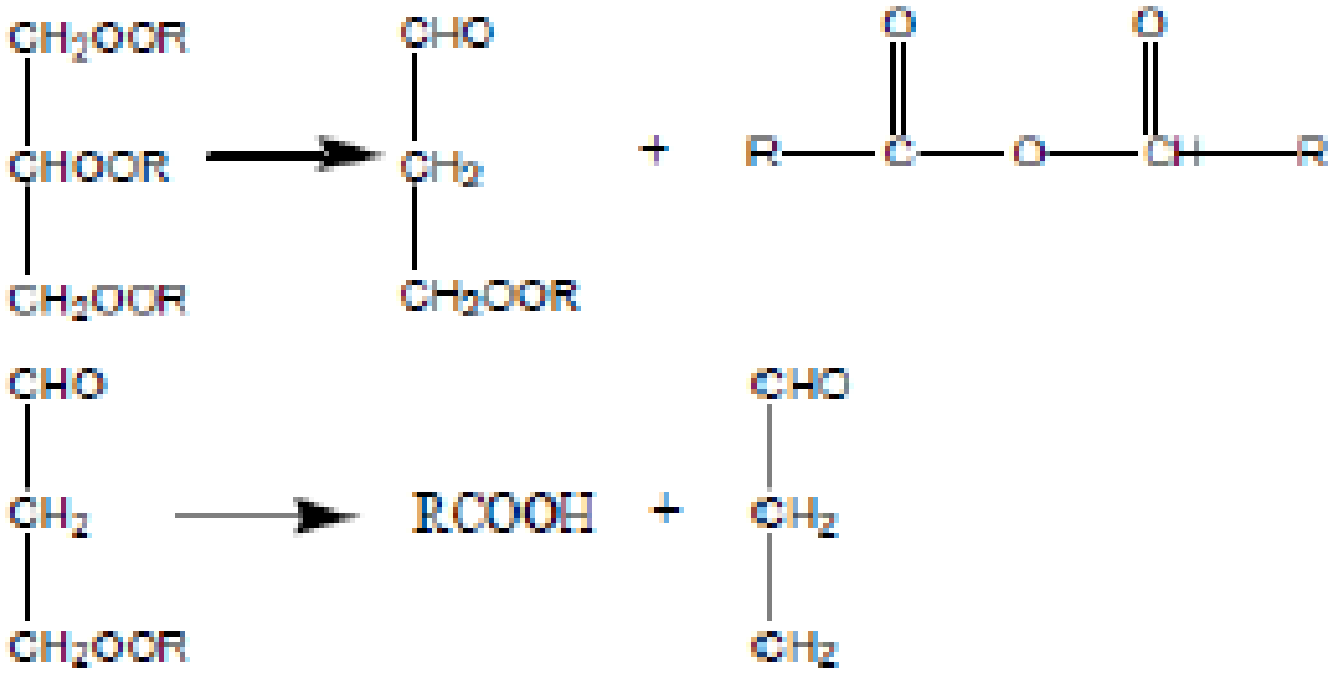
in high temperatures.

High temperature reactions deteriorate the quality of foods and

* lead to darkening
* viscosity increase
* iodine value decrease
* smoke point reduction
* acid value elevation
* irritant odor

Thermal Degradation

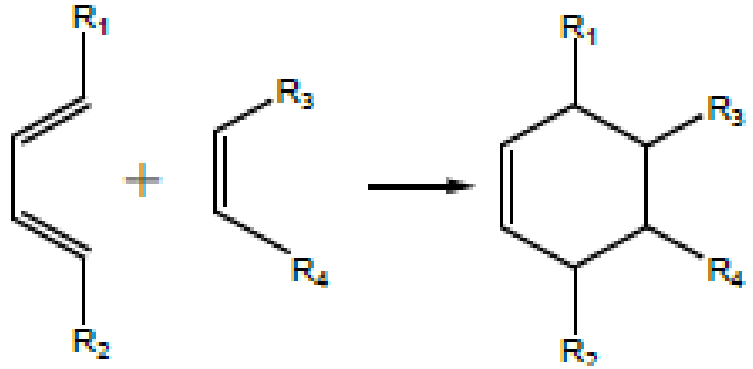
Both saturated and unsaturated fatty acids undergo oxidative or non-oxidative thermal degradation in high temperatures.



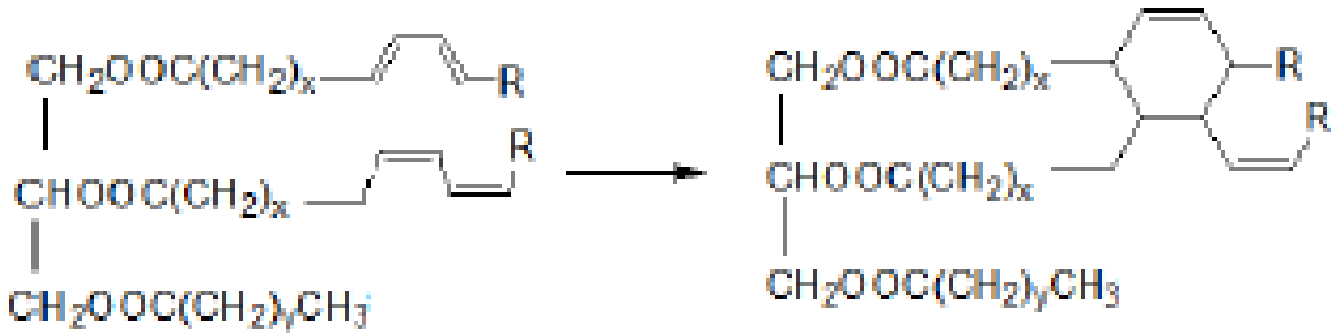
Non-oxidative thermal degradation of saturated fatty acids

Thermal Polymerization

The thermal polymerization of lipids might be oxidative or non-oxidative reactions.



Inter-molecular non-oxidative thermal polymerization of lipids



Intra-molecular non-oxidative thermal polymerization of lipids

Lipid Processing

The production of oils takes place in three steps:

* Cleaning

* Extraction

* Refining

Cleaning: The raw materials used in oil production should be delivered to production sites as soon as possible and foreign bodies should be removed.

Extraction: Oils and fats from animals and vegetable tissues can be extracted with:

* Warmth

* Press

* Chemical solvents

Refining: The refinement process is required to remove some impurities.

Refining steps:

Hydration: The first stage of refining is the separation of fine particles and colloidal substances.

Neutralization: To remove free fatty acids and part phospholipids and pigments, NaOH solutions of appropriate concentrations are added to heated oils.

Degumming: Phospholipids are removed in this step. Carbohydrates and proteins are also removed in this step.

Bleaching: Bleaching removes colored substances from oils and their components.

Deodorization: The off-flavor compounds are destroyed by water steam and are then distilled away.

Winterization: These fats are cleaned by cooling and filtration and refined to a certain extent.

Hydrogenation of oils

The unsaturated fatty acids present in the oil can be converted to saturated fatty acids by using high temperature catalysts such as nickel and cobalt. As a result, liquid oils become solid fats (margarines) .

Margarines also contain certain amounts of animal fat. The most common curing method is the hydrogenation method. Margarines mainly contain hardened fat, sour milk and additives. Hydrogenated oils are very strict. Edible oils are often partially hydrogenated because this is undesirable.

The digestive metabolism of lipids

Lipids are first broken down into glycerin, fatty acids, mono-, di- and triglycerides and thus absorbed and get into the bloodstream. Then they break down into fatty acids and glycerin that can be used by the cells, and are then metabolized as follows:

1. Fatty acids and glycerin are metabolized in all tissues except the central nervous system as an emergency power source.

2. Glycerin and fatty acids combine in the cells of the liver or adipose tissue and are stored as triglycerides.

3. Glycerin is converted to glucose. It is metabolized as glucose or stored as glycogen or fat. Fatty acids are stored as energy sources.

The functions of lipids in the diet

1. They are energy sources. Because lipids are stored in the body, they can also be used as a source of calories that are consumed when needed.
2. Since they are source of fat-soluble vitamins (A, D, E, K), we absorb these vitamins together in the lipids that we ingest with nutrients.
3. The body cannot synthesize certain fatty acids (exogenous fatty acids). Such fatty acids must be provided with the lipids we eat.
4. The digestibility of fat is very high. The daily fat requirement of an adult is 75 grams.
5. Fats and lipids form the building materials of the cell.
6. Since lipids remain in the stomach more than other nutrients , they ensure longer feeling of fullness.
7. Lipids are appetizing because they give the food the taste and aroma.
8. Oils accumulated under the skin protect the body from external influences and cold.
9. A small amount of fat that accumulates around the kidneys and other organs supports these organs.
10. Determines the factors of beauty and ugliness.

DETERMINATION METHODS OF LIPIDS

Chemical features of lipids used to separate them from the other components in foods. These are physical features, their solubility in organic solvents and spectroscopic properties. The analytical techniques based on these principles can be categorized into three different types:

1)Solvent extraction

2)Non-solvent extraction

3)Instrumental methods.