Paper No.: 02

Paper Title: The Principles of the Food Processing & Preservation

Module No :19

Module Title:Principle of processing by baking and frying

19.0 FRYING

Frying is the oldest food processing methods that involves simultaneous heat and mass transfer. It changes the sensory and nutritional characteristics, as a result of complex interactions between food and oil. Frying provide unique flavor and taste to food.During frying lots of changes takes place in food both desirable and undesirable that depends on the characteristics of the food, oil type, surface/volume ratio ofthe oil, rate of air incorporation of into the oil, temperature,heating process, length of immersion and container type. When oil is subjected to high temperature and atmospheric air adverse reactions induced result in generation of highly oxidized and toxic products.

19.1Frying process

During frying process heat and mass transfer takes place simultaneously that modifies the food surface, formation of crust takes place that preserves flavor and retains juiciness. Cooking takes place during frying make chewing and digestion easier. Frying temperature is very heterogeneous; it is highest at periphery and lowers in core. Average frying temperature ranges from 150-200ęC. The rate of heat transfer during frying influenced by the composition of the food and its properties of heat and mass transfer like thermal conductivity, thermal diffusivity, specific heat and density. These characteristics change during the frying process, once oil and food are altered. Frying can be done by batch and continuous fryers, also accomplished under atmospheric, high or low pressure and even under vacuum.

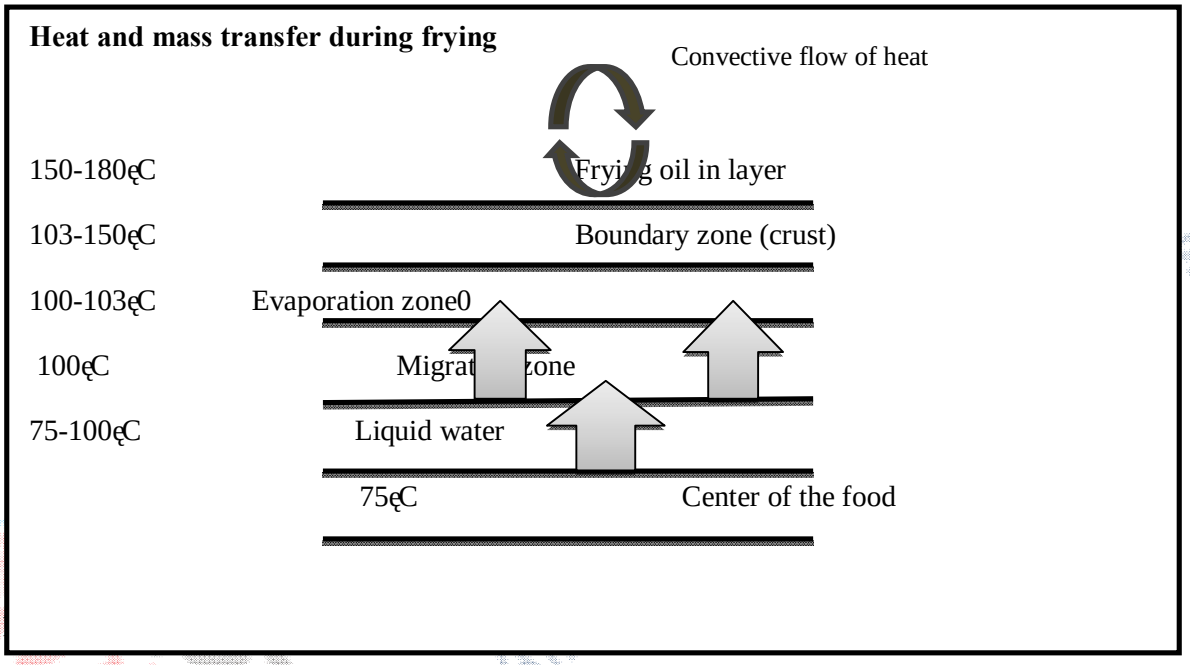
19.2Components of frying

Basic component of frying are fryer, filters, ventilator, frying feed

Fryers are mainly of two types: batch and continuous

19.3 Selection of frying medium

An important criterion for the selection of frying oil is the stability that is related to fatty acid composition, price and availability. Frying oil should not contribute to off flavor, no greasy surface, resistance to excessive smoking, uniform quality fried product, economical to use for long time, resistance to gumming. Good oil should give expected, specific product textures.



19.4 Steps of dehydration during frying

Frying involve five stages of dehydration of oil and food quality.

A. Zone OA-break in oil: - This is initial stage of frying when food start to picks little amount of oil and get white, raw, ungelatinized starch at the center of fry.
B. Zone AB-fresh oil: - At this stage slightly more absorption of oil takes place and food surface become brown and crispy at surface.
C. Zone BC- optimum oil: - Food absorbed at optimum amount of oil and get dark brown. Food products give delicious odour and surface is crispy.
D. Zone CD- degrading oil: - Viscous dark oil adhere on surface and product become dark or spotty, hard surface and lumpy.

E. Zone DE- runaway oil: - At this stage oil should be discarded because center of food is not fully cooked, also gives off-odour and off-flavor.

19.5Changes during frying

19.5.1 Physical and chemical changes in fried foods

Physical and chemical changes in fried foods as shown in Table 2 depend on the composition of food. Various changes occur during frying are; Fat concentration increased and its composition altered, loss of water, maillard reaction, gelatinization, protein composition get altered, formation of heterocyclic compounds, loss of vitamin, minerals and antioxidants, flavors develop, crispiness is produced and pores are formed, leading to distinctive texture and sensory characteristics. Sometimes maillard reaction generates toxigenic and carcinogenic compounds like acrylamide.

Table-2. Physical and chemical changes in fried foods

Physical Parameter	**Change during deep-frying**	**Reason**
Refractive Index	Increases	Accumulation of conjugated fatty acids
Density	Increases	Polymerized triacylglycerols
Dielectric Coefficient	Decreases	Polar oxidized components disturbed by free fatty acids and water
Colour	Becomes more intensive and darker	Maillard reaction products of amino acids(protein) and unsaturated carbonyl compounds
Conductivity	Increases	Polar compounds
Surface Tension	Decreases	Polar compounds
Smoke Point		Volatile oxidized decomposition products
Specific Heat	Increases	Polar compounds
Viscosity	Increases	Polymerized triacylglycerols
Chemical Parameter		
Anisidine value	Increases	Secondary oxidation products

Iodine value	Decreases	Formation of oxidized fat products
Peroxide value	Increases but can also decreases	Primary oxidation products
Polar compounds	Increases	Oxidized and polymerized degradation products including unchanged polar fat components
Polymerized triacylglycerol	Increases	Oxidized and not oxidized polymerized triacylglycerols
Acid value	Increases	Formation of oxidation products with free carboxyl groups

A. Color, taste, and flavor changes caused by the oil

During frying mainly three components brings about changes in food: water, oxygen and high temperature, that results in hydrolytic, oxidative and thermal changes respectively. Main factor that effect the change in color are the oil type, storage and thermal changes interfacial tension between the oil and product, temperature and length of frying, moisture content, size and characteristics of food surface and pre-frying treatments. Lipid undergoes oxidation and polymerization gives raise to number of volatile and non-volatile compounds. Lipids also affect the thermal stability as saturated lipids are more stable than unsaturated ones. Unsaturated fatty acids are rapidly lost in frying process that alter the balance between saturated and unsaturated fatty acid and increases the development of off-flavor. Also, long term reuse of oil can leads to accumulation of undesirable substances.

B. Changes in texture

Texture developed during frying process is a result of the combination of changes in proteins, fats and carbohydrates polymers, and there interactions. The development of pores is a major structural change that is formed by evaporation of water and formation of capillaries. These poresaffect the mechanical properties of food, its texture and acceptability. A superficial crust is quickly formed, acting as a barrier to evaporation, decreasing the loss of water and keeping the inside of the food moist.

19.5.2 Nutritional changes

A. Changes in the lipid fraction of foods

Lipid content of food has been increased due to absorption from frying oil and digestibility also improved. Frying process can also produces trans-fatty acid that results in increasing the risk of cardiovascular diseases. Trans-fatty acid formation depends on: frying conditions, frying materials and method of TFA measurement.

B. Changes in protein content

Heat treatment during frying process can reduce the amount of proteinand destroy some amino acids, changing the quality of protein composition in food and reduces the amino acid contents. Maillard reactions occur during frying decreases the bioavlaibility of lysine.

C. Content of minerals, vitamin and antioxidants

The content of minerals seems to have no significant loss and some minerals can increase with fryingdue the effect of concentration.Vitamins are thermo-sensitive and their oxidationdepends on the internal temperature of the food andfrying process. Vitamin C usually is the most thermo-sensitive and thiamine, riboflavin,niacin and B6 are the most frequently affected bythe process. High temperature during frying also destroys retinol, carotenoids and tocopherolsthat results in changing oil flavor and color.

D. Alterations in starch and indigestiblepolysaccharides (fibers)

Starch getsgelatinized at high temperature of frying process as amylose and amylopectin dissolve in water with heatforming a polymer network. Gelatinization occurs after denaturation of globular proteins at high temperatures and involvescarbohydrates, proteins, lipids and water. Rigid structures of food get lost and become soft, on further heating crispy layer will form on fried products. On the surfaceof food, where the water content is much lower thanin internal layers, the gelatinization is not so intense,so starch granules partially retain their crystallinestructure.

E. Changes of the oil caused by heating

Hydrolysis, oxidation, isomerization and polymerization are the various reaction that occurred during deep-fat frying resulted in the generationof free fatty acids, small molecular alcohol, aldehyde,ketone, acid, lactone,di-glyceride, mono-glyceride, trans isomers, monomer, dimer, oligomer, cyclic and epoxycompounds.Oxidative stability of frying oil depends on degree of unsaturation, metals, free fatty acids, mono and di-acylglycerol.

19.6Baking

Baking is a food cooking method that uses heating by convection rather than radiation. Bread is the most common baked item. In addition to bread, baking is used to prepare cakes, pasteries, pies, tarts, quiches, cookies, crackers and more. There are three basic steps in baking: first is mixing of ingredient to make dough, then dough is baked and finally it is cooled. Baking includes number of physical and chemical reactions that affect flakiness, tenderness, amount of browning and crumb structure.

19.7 Ingredients

Selection of flours: The characteristics of flour depend on the wheat variety from which it is milled, its location and growing conditions. Wheat generally classified as hard wheat and soft wheat. Strong flour obtained from hard wheat has greater quantity of protein that is 13-14%, used for bread making and other yeast products. Weak flour obtained from soft wheat has low protein content that why they used in the production of cakes, cookies and pastries. Some other kind of flour are also made for baking are bread flour, self-rising flour, all purpose flour, biscuit flour, cake flour and enriched flour.

Fat and tenderizers: Fat used in baking is called a shortening because it shortens gluten strands. Fat lubricate or moisten the particles to prevent sticking. It enhances the keeping quality, acts as a tenderizer and add flavor. Fats assist in leavening when used as a creaming agent and it also provide flakiness to puffy pastry, pie dough and similar products. Different type of fats used for baking purposes depends on melting point, flavor, softness and hardness at different temperatures and ability to form emulsion.

Water: Water plays an important role in gluten development as it affect the toughness and tenderness. Gluten development depends on the concentration, hardness and pH of water. When

water concentration is low no gluten network formation take place and at high water concentration gluten network form are weakened. Hard water contains calcium that strengthens gluten making dough too elastic and hard to work. If water is too soft dough becomes slack and sticky. For the proper development of gluten pH should be in range of 5-6.

Sugar: Sugar or sweetening agents provide sweetness and flavor to the bread. They create tenderness and fineness of texture, partially by weakening the gluten structure. Sugar provides food for yeast and gives crust color. Sucrose, refined sugar, molasses, brown sugar, fondant,

Leavening agent: Leavening is the process of increasing the area of dough by creating air bubbles of gases especially carbon dioxide, air or water vapor.

a.) Air: Air is leavening gent present in all batters and dough. Air is responsible for small increase in volume but effectiveness of water vapor and carbon dioxide as a leavening agent depends on upon the distribution of air. The amount of air incorporated depends upon the extent of mixing of batters, viscosity of batters, volume of ingredients and length of time elapse before baking.

b.) Steam: As water expands 1600 times when it converted into steam that why even a small amount of water can cause good amount of leavening action. Steam alone cannot be used as leavening agent so it must be combined with that of air and carbon dioxide.

c.) Chemical leavening agents: Most common chemical leavening agent is baking powder, sometimes ammonium carbonate, baking soda and acid ingredients are also used. Baking powder can be used single or in combination with another acid. Baking soda when react with acid it release carbon dioxide according to following reaction:

$NaHCO_3 + HXNaX \rightarrow H_2O + CO_2$

It also contains corn starch act as filler that serves two purposes. Firstly it acts as a buffer between soda and acid, and secondly it prevents soda to react when exposed to moisture present in air. Tartrate powder, phosphate powder and combination of powders used as acid ingredient but tartrate is most commonly used. Tartrate leaves a tasteless residue that act as cathartics and diuretics. Although sodium bicarbonate does not require an acid for release of carbon dioxide as it decomposes in presence of heat. But sodium carbonate is the end product of the reaction that leaves an unpleasant taste. Acids are commonly required to prevent this kind of unpleasant taste that is provided by sour milk, buttermilk and fruit juices.

d.) Yeast: yeast is a unicellular micro-organism that decomposes sugar into alcohol and carbon dioxide at pH 4-6 and temperature 30˚C. *Sacchromyces cerevisiae* is a particular strain of yeast used in baked product mainly in two forms: Compressed yeast and active dry yeast. Compressed yeast is the most active form of yeast used for bread baking, but unstable at room temperature. Active dry yeast is more stable as its shelf life is over six month.

Salt: It is mainly used as a flavoring agent. It also strength the gluten structure, improves the structure of dough and makes it more stretchable. Gluten absorbs more water and carbon dioxide in presence of salt, allowing dough to expand more. Salts also play an important role in controlling the fermentation and growth of wild yeast.

Oxidizing agent: They improve the handling characteristics of the dough and the specific volume and texture. Oxidizing agents alter the mechanical properties of dough by causing the formation of additional disulphide bonds between gluten molecules. Potassium bromate is most commonly used oxidizing agent.

19.8Mixing and dough development: It is a complex processes that involves blending of ingredients, dough formation and development. The special phenomena that occur during mixing are the air cell formation, hydration of the components and oxidation. Air cells provide uniform texture to the bread and it is a necessary part of leavening process. Gases formed by leavening agent collected inside the air cells and cell walls get stretched and enlarged. In hydration ingredients absorb water and react in different ways. Starch undergoes gelatinization and provides structure to baked goods that is not possible without hydration. Water is necessary for the formation of gluten and it requires for yeast activity. Hydration also helps in controlling the temperature of dough or batter. Next is oxidation that occurs when oxygen from the air reacts with protein and other component. Oxidation helps in bleaching of flour to whiten the bread, provide better structure and bread with fewer flavors.

19.9Dough development: Dough development is an important phenomenon during baking. Gluten plays major role, as it provide structure to the bread, glutenin and gliadin are the two proteins that form a stretchable substance called gluten. During mixing glutenin and gliadin protein uncoiled, stretched and intertwined to form an elastic network, called gluten

network.Next step is coagulation of gluten protein by heat that results in firming or hardening. Bread holds its shape as soft, pliable bread dough is converted into firm bread crumb. Dough development generally takes place by straight dough and sponge systems. The activated dough development process, continuous dough making process and no-time dough making process are also used for dough development. The proportion of ingredients used for dough making depends upon the method employed, type of flour used, time given for fermentation and nature of final products. When the ingredients are mixed together dough development takes place and air is mixed into dough. The oxygen in the air reacts with the gluten and helps strengthen it and make it more elastic. The mixing action generates an elastic network by stretching and aligning the gluten strands. When dough reaches ideal stage of development it is said to be mature. Over mixing should be avoided as it results in poor loaf volume. Dough relaxation allows period of rest so that gluten strands adjusted to new length and shape and become less tight.

19.10Baking and changes during baking

There are several changes occur in the baking process like melting of fats, formation and expansion of gases, coagulation of protein, gelatinization of starches, inactivation of yeast and other micro-organism, escape of water vapours and gases, crust formation and browning.

Melting of fat: Melting of fats take place between 32˚C- 55˚C and different fat have different melting points. Fat that mixed into dough trap air, water and leavening agents and all these components are released during melting of fats.

Formation and expansion of gases: Carbon dioxide is mainly responsible for leavening of baked goods, released by the action of yeast, baking soda. Some gases leaven the product without heating (carbon dioxide) while other gases require heating (Steam). Expansion of gases helps in tenderization of product.

Inactivation of yeast and other micro-organism: Yeast inactivated when interior temperature reaches to 60˚C, while other micro-organisms survive to slightly higher temperature.

Protein coagulation: Coagulation of protein starts slowly at 60-70˚C and completed at 85˚C, as the process going protein strands continue to stretched and expansion of gases takes place. Temperature at which coagulation begins and completed depends on the ingredients present in dough. Temperature plays an important role in coagulation, if it is high coagulation start soon before expansion of gases and at low temperature protein does not coagulate enough.

Starch gelatinization: Starch providessoftness and bulkiness to the structure. Starch gelatinization starts at 40˚ C and continue throughout baking till 95˚ C.

Release of water vapour and gases: Release of gases and loss of moisture from surface helps in crust formation.

Browning and crust formation: Chemical changes occur to starches, sugars and proteins cause browning.Browning takes place when the interior temperature rises above 150˚ C and in presence of dry surface. Most of crust browning takes place due to maillard reaction. Chemical changes during browning reaction contribute to flavor and appearance of baked products.

After Baking: It involve number of process that takes place when baked product is removed from oven

Cooling: When the products removed from oven moisture continue to escape causes contraction and surface is drier than interior crumb. Moisture content tries to distribute throughout the product result in softening of crispy crust. Protein and fat solidify that make texture firmer and starch continues to gelatinize. Starch retrogradation takes places as starch molecule becomes more solid when product cooled.

Staling: It is change in texture, aroma and structure of baked goods due to lose of moisture by starch granules. Stale bread have lost their fresh baked aroma and become firm, dry and crumbly. Staling of bread is higher under refrigerated condition and chemical staling of bread is partialreversible on heating.

After baking baked products are store at room temperature and protected from air and moisture. Sometime reheating of bread is done to refresh as staling is partially reversible during heating.