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FOOD TECHNOLOGY
FACT SHEET

Deep-Fat Frying Basics for Food Services

Fryer, Oil and Frying Temperature Selection

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Introduction

Frying is one of the oldest methods known to human kind for preparing food. Fried foods are among the favorites for people around the world. The Latin and Greek words for frying originate from those used for roasting, suggesting that frying may have developed from roasting.

The simplest deep-fat frying is conducted in a kettle of oil heated on a stove or over an open fire. Small batches of food are immersed in hot oil and removed when fried as determined by the experience of the cook. The first real technological advance in frying was the introduction of continuous cookers. The development of continuous fryers provided a boost for the commercial development of frying.

Deep-fat frying is the most complex edible fat and oil application. Frying fat influences many qualities of the finished product such as flavor, texture, shelf life and nutritional attributes. The book entitled "Deep Frying, Chemistry, Nutrition, and Practical Applications," edited by E.G. Perkins and M.D. Erickson is an excellent source for readers interested in the fundamentals of deep-fat frying.

This fact sheet is the first of a series that will provide technical and practical information on the science and technology of frying. It will focus on basic information on fryer and oil selection for food services. Frying temperatures for several food applications also will be discussed. Fryer maintenance, regulations and industrial frying will be covered in forthcoming fact sheets.

Food Service Frying

In food service, frying is typically conducted on demand and, as a result, will peak and ebb throughout the day. Depending on the menu and local eating patterns, fryers will usually be operated at full capacity for a few hours a day, intermittently for a few hours and be idle the reminder of the time. Operating a fryer on an intermittent basis is the primary reason that frying oil must be discarded and replaced periodically. During the idle and low production periods, the oil is subjected to thermal and oxidative stress more than it is during the active frying process. If the fryers were operated without interruption and the oil was filtered regularly, frying oil would rarely need to be discarded.

Frying oil turnover is an indicator of how much stress the oil is subjected to in a daily operation. Oil turnover in hours for a food service operation is defined as:

$$\text{Oil turnover} = \frac{\text{Total pounds of oil in the fryer}}{\text{Average pounds of oil used per hour}}$$

For oil turnover calculations, oil usage is based on the total time the fryer is "on." If the fryer is turned off during idle periods, the "lay" time would not be counted. If the fryer remains on, even if it is set to a lower temperature, the time would be counted for oil turnover calculation.

The product absorbs oil during a frying operation. The range of oil absorption for food service items vary 8 to 25 percent depending on the type of the product fried and the frying conditions. Make-up oil must be added periodically to maintain the proper oil levels in the fryer.

The frying capacity of a batch fryer is usually based on the maximum pounds of frozen French fries produced per hour. For example, a fryer that holds 32 pounds of oil and can produce 50 pounds of French fries per hour will require an additional 4 pounds of make-up oil every hour based on the approximation that frozen French fries, also referred to as "par-fries," will absorb 8 percent oil during the finish frying. At the end of 8 hours, 32 pounds (4-pounds make-up oil/hours X 8 hours) or one fryer volume of oil will be added. In this example oil turnover is 8 hours. Most batch fryers would have turnover rates in the 5- to 12-hour range for continuous production. A 5-hour turnover would be sufficient to maintain good oil quality under most frying conditions. Extending the turnover to 12 hours creates much more stress on the oil. In practice, fryers may be heated to the set temperature 30 minutes to 1 hour before frying operation starts. After start-up, fryer usage will vary with continuous usage required a few times a day separated by slow idle periods. Therefore, the actual oil turnover for most food-service fryers will be much slower than the rate calculated for continuous operations. Fryer oil quality cannot be maintained in batch fryers with a turnover rate of greater than or equal to 20 hours. Even with careful control of all other aspects of frying, including temperature, moisture, crumbs, seasonings and filtration, the oil will deteriorate after a few days of usage and has to be replaced completely.

Fryer Selection

The types and quantities of food to be prepared are the major considerations for fryer selection. Foods that can be fried in the same fryer without compromising quality can be grouped together for calculating fryer volume requirements. Foods that exchange fat, transfer flavor, change oil color or impart other detectable characteristics should be assigned to separate fryers. The peak frying demand for each food group would determine the fryer volume requirement. Fryer sizes for food services vary from 15 to 45 pounds for bench models and from 30 to 200 pounds for floor models based on fat holding capacity. Smaller fryers allow more flexibility in matching capacity to varying demand during the day and dedicating separate fryers for specific foods in order to avoid flavor, seasoning and fat exchange. Smaller fryers also can be put in service as needed, thereby, protecting oil from unnecessary heat stress, reducing heating costs and improving the rate of oil turnover.

Fryer design must be matched to the type of the product to be fried. For example, French fries can be prepared in fryers with deep and narrow baskets. Doughnuts are usually fried in wide, shallow fryers specially designed for this product.

Fryers with cool zones, reservoirs of oil below heating surfaces that remain well below frying temperature, should be selected for applications where crumbs accumulate rapidly or the product contains ingredients such as sugar or lecithin that can quickly degrade oil. The cool zones limit scorching and carbonization of particulate. However, cool zones do not provide effective crumb control and add extra oil volume that is not used for frying.

Divided fryers can be used to separate products into smaller volume operations. A divided fryer prevents oil transfer across the fryer but may not prevent heat transfer unless separated by insulation.

In general, electrically heated fryers are easier to install. Gas fryers are usually preferred for high performance and heavy-duty usage. When using fryers with electric heaters, it is essential that the elements are completely immersed in oil during heating and frying. Otherwise, an exposed part of the element could overheat and create a fire hazard. Installation of gas fryers requires compliance with regulations regarding gas piping, combustion air and venting of combustion gasses.

Frying Oil/Fat Selection

The products used for frying range from unhydrogenated fully refined fats and oils to specially hydrogenated products designed for frying. Fry-life, mouthfeel, product appearance, specific product requirements, ease of handling and cost are the major criteria for selecting a frying fat for a given application.

A useful way to determine the suitability of an oil for frying is to consider its inherent stability to oxidation. Inherent stability numbers relate to relative reaction rates of unsaturated fatty acids with oxygen. Therefore, an oil with a low inherent stability number is less susceptible to oxidation during frying. Calculated inherent stabilities of common fats and oils are shown in Table 1. The inherent stability calculation assumes that all oils are refined, bleached and deodorized from reasonably good quality crude oil.

Regular frying shortenings generally have Active Oxygen Method (AOM) stabilities in the range of 40 to 100 hours and melting points 194 to 239°F. Heavy-duty frying shortenings with AOM stabilities of 200 to 300 hours and melting points in the range 217 to 230°F provide long fry-life. Shortenings are available in 50-pound cubes and 5-pound bricks. A smaller size is easier to handle for food service operations. Melting shortening requires careful handling to avoid possible damage to fryer and shortening.

Pourable frying fats are popular due to their convenience in handling. They range from clear to opaque fluids at room temperature, 68°F. Soybean, canola and palm oil are examples. In general, liquid fats are not as stable to oxidation as their hydrogenated counterparts. The lower stability oils are cheaper but develop polymers that build up on the fryer and frying equipment, making fryer cleaning difficult and expensive. High stability liquid oils with AOM stabilities as high as 350 hours are also available. They are convenient to use but usually cost more than solid fats with similar fry-life.

Specific requirements of a product, such as appearance, seasoning adhesion, mouthfeel and fat retention, are important considerations for frying oil selection. For example, if doughnuts are being prepared to serve fresh, a pourable frying oil can be used. However, if doughnuts are to be packaged for later consumption, they should be fried in a shortening that solidifies at room temperature, since liquid oil slowly drains out of the doughnuts and pools in the package.

A number of antioxidants are approved for use in edible oils and can be added to the oil prior to use to increase oxidative stability. An antioxidant protects oil during shipment and storage. However, most antioxidants degrade during heating and frying and will no longer protect the oil during frying. Food grade methyl silicone or dimethyl polysiloxane is often added to frying oils and helps to extend the fry-life. It also retards foaming. Silicone is not soluble in oil but is dispersed as microscopic droplets.

A wide variety of plastic or solid fats are available for frying applications. These products range from refined palm, coconut and palm kernel oils to the animal fats lard and tallow. In some cases these are blended with other refined vegetable oils, hydrogenated fats and oils and with each other. The assurance of expected quality most often relies on experience with supplier, working closely with supplier and actual performance tests. For example, McDonald's requires that the par-fried potatoes prepared for their restaurants be fried in a custom designed "Mac Oil."

It is always a good idea to prepare a comprehensive list of specifications for the frying fat selected. The list of specifications is needed to address any performance, nutritional and labeling issues that may arise. Oil specifications also provide purchasing flexibility and support competitive pricing.

Frying Temperature

The normal temperature range for food service frying is 325 to 375°F. However, higher temperatures of 375 to 400°F also are used. Most foods cook rapidly in the 325 to 375°F range and develop a golden color, crisp texture and good flavor. The products fried in the normal temperature range absorb 8 to 25 percent oil. Frying time is longer at lower temperatures. Frying at lower temperatures results in lighter color, less flavor development and increased oil absorption. High-temperature frying leads to thinner crusts and less oil absorption. Crusts cook faster than the interior of some products during high-temperature frying. In such cases crusts usually have to be over fried in order to get the interior cooked properly.

In batch frying the temperature of the oil drops about 86 to 104°F when product is added to the fryer. The temperature drop can be higher for frozen foods. The guideline is that temperature of the oil should recover to its set point at least by the end of the frying cycle so that the fryer will be ready to fry the next batch. Oil oxidizes faster at higher temperatures. For example, increasing the frying temperature from 325 to 350°F more than doubles the oxidation reaction rate; therefore, frying temperature even within the normal range should be selected very carefully. The midpoint of the normal frying range, 350°F, is a good starting point to establish the frying temperature for a new product; however, any frying temperature that achieves the best flavor, texture and eating qualities for the product should be used. The principal quality index for deep-fat frying should be sensory parameters of the food being fried. It is important that fryers are checked on a regular basis to ensure accurate temperature control. A number of digital thermometers with calibration devices are available for this purpose.

References

Perkins, E. G. and M. D. Erickson. "Deep Frying, Chemistry, Nutrition, and Practical Applications," Edited by E. G. Perkins and M. D. Erickson. AOCS Press. Champaign, IL. 1996.

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Table 1: Inherent Stability of Common Fats and Oils

Oil	Inherent Stability
Safflower	7.6
Soybean	7.0
Sunflower	6.8
Corn	6.2
Rapeseed (Low Erucic Acid)	5.5
Cottonseed	5.4
Rapeseed (High Erucic Acid)	4.1
Peanut	3.7
Lard	1.7
Olive	1.5
Palm	1.3
Tallow	0.86
Palm kernel	0.27
Coconut	0.24

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