*Richard F. Stier*
*Sonoma, CA, U.S.A.*
*Rickstier4@aol.com*

# Deep-Fat Frying: Understanding Leads to Optimization

Cereals and grains are intimately linked with deep-fried foods the world over. When walking through your local supermarket, identify all the foods that are fried and check to see how many have some kind of cereal-based ingredient. Extruded snacks? Yes. Corn and tortilla chips? Yes. Battered and breaded seafoods, meats, vegetables, and other snacks? Yes. There are even coated French fries.

Today, fried foods are under fire because they have been linked to obesity and many other diseases associated with high-calorie diets. Fried foods are not bad in their own right, but too much of anything is not a good idea. Fried foods are high in calories because they contain fats, which are high in energy (9 cal/g) compared with carbohydrates and proteins (4 cal/g). Yet, fried foods are consumed the world over. Why? They taste and smell good and have a rich mouthfeel and crispy bite. They also provide pleasure, and most people seem to take pleasure in good food. Think of beignets and powdered sugar in New Orleans, a fresh honey bun, or a well-prepared battered and breaded fish as part of a fish and chips dinner. In addition, fried foods are usually very safe from a microbiological standpoint. Frying temperatures render foods free of pathogens. The key is to enjoy these foods in moderation, not to eat them for each and every meal.

There are technologies that can help processors produce fried foods that are lower in fat but that still retain the taste and texture consumers enjoy. For example, the use of cellulose-based components in breadings and batters can reduce oil pickup, as can the application of technologies such as vacuum-frying. The key to optimizing frying operations is complex, however. Processors need to make a commitment to understanding their frying practices, a part of which is making the commitment to understanding the relationship between oil chemistry and food quality. In 1967, Robertson (5) elucidated six key points for quality frying:

1. Design, construction, and maintenance of equipment
2. Proper operation of equipment
3. Proper cleaning of equipment
4. Minimizing exposure to UV
5. Keeping salt and metals away from oil
6. Filtering regularly

In 1993, Stier and Blumenthal (8) proposed one more point: measuring chemical markers of oil degradation. They suggested that fryer operators should begin testing their oils to better understand what happens to the oil during frying and relate the acquired data to food quality. This makes sense because frying is one of the most dynamic of all food-processing systems. Researchers have isolated literally hundreds of compounds from frying oil—a product that when fresh is quite pure and contains between 96 and 98% triglycerides. In 1981, Fritsch (3) created a diagram (Fig. 1) that demonstrates how dynamic frying truly is.

A recent alliance, the Fitfrying Partnership (www.fitfrying.com), was created as a "collaborative effort of nonprofit and for-profit companies with a mission to become the go-to resource for the Foodservice industry for advice and guidance to make deep-frying a healthier cooking technique for Foodservice operations and, ultimately, their customers." The group lists a number of steps for healthier frying processes, including

1. Selecting the right fryer
2. Selecting the right oil
3. Selecting the right food
4. Following proper processes
5. Following proper maintenance procedures

These steps are the logical outgrowth of Robertson's basic principles for quality frying from almost 50 years ago (5).

### Understanding What Goes on in the Fryer

The primary goal of frying is to produce safe and wholesome foods. The first recommendation that came out of the 3rd International Symposium on Deep-Fat Frying held in Hagen,

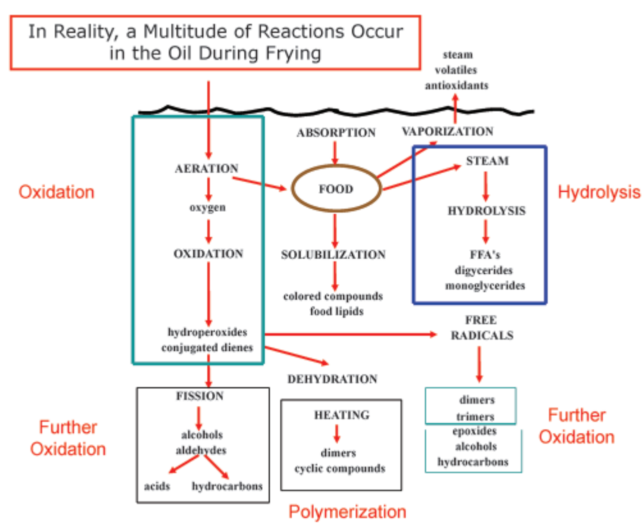


**Fig. 1.** Oil reactions during frying (3).

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Germany, in 2000 was that "The sensory parameters of food are the prime quality index" (2). However, producing consistently high-quality food comes with the cost of the time and effort needed to understand what goes on in the fryer. One reason the fried snacks produced by many large snack food manufacturers are of such high quality is that these manufacturers have made the effort to understand frying oil and how oil quality relates to process parameters affecting the quality of their products.

The first step in understanding what goes on in a fryer, whether it is a large system producing hundreds of pounds of coated cheese sticks or a small restaurant fryer, is to establish a baseline for the operation. Ideally, this should be done when a fryer is first installed, so the operator develops an early understanding of the frying system. Doing this will provide the operator with the information needed to properly evaluate how proposed changes will affect products and operations. An example of a lack of understanding of process operations occurred recently. In the last five years many operations rushed to change their cooking oils to no or low trans-fat alternatives only to find that both their products and operational efficiencies changed for the worse. Good baseline data would have helped to properly evaluate the change and to better understand the potential risks and benefits. In deep-fat frying operations, good baseline data are developed by determining the chemical, physical, and sensory parameters of oils and foods that are typical of normal frying operations. Once the data have been gathered, any changes to the frying system can be evaluated intelligently and without prejudice against the baseline.

So, how does one go about conducting a baseline study? There are two basic steps in the process: evaluation of fresh oil and development of baseline data. Evaluating fresh oil is important for several reasons. The first is to verify that the analytical values of the oil match the established specifications. The second is to set the stage for evaluating fryer startup when conducting the baseline study. For example, one would assume that the test results for an oil sample collected from a fryer after the oil has been heated but before frying is initiated would be very similar to the fresh oil. This is not always the case, however. Testing heated oil before frying is initiated can provide insights into whether the fryer has been properly cleaned. Failure to properly remove water and caustic cleaners will result in a spike in the soap content of the oil (7).

Developing baseline data is more complicated. It can vary based on what a processor wishes to learn from the study and how much the processor wishes to spend in building the baseline. Ideally, the more information one gathers, the greater the potential one has to paint a complete picture of the frying system. One issue that must be addressed upfront, however, is ensuring that the processor has someone in-house, a consultant, or a competent laboratory that can review the data developed and explain what they mean. This is a greater challenge than it might seem because few people really understand the science and technology of frying.

When developing a baseline study, the processor must design a sampling schedule, decide which comparative tests should be conducted, develop a means to monitor fryer temperatures and fluctuations, and record and evaluate the food being produced. The latter point includes not only how much product is produced, but how the quality of the product changes over time. As part of evaluating food, the operator should also conduct shelf-life studies of product collected at different times during frying. For example, an extruded grain-based snack produced in a kettle-type fryer would have a shorter shelf life toward the end of the useable life of the oil. This leads to the last, and perhaps the most important, point of baseline studies: what constitutes the end point of the project? Is it a chemical marker? Food quality? Or, something else? Hopefully, the operator will utilize food quality as their endpoint marker, because, as noted above, food quality is the objective of developing a quality frying program.

Oil testing and evaluation is an issue that processors need to assess with care. The more testing that is done, the higher the cost of the project. With additional testing and evaluation, however, there is a greater potential to better understand the frying system. Tests that might be done include

- Free fatty acids
- Total polar materials
- Polymeric triglycerides
- Soaps
- Oil color
- Metals
- Fatty acid profile
- Suspended solids
- Iodine value
- Oil stability index (OSI)
- Hexanal
- Tocopherols
- Anisidine value
- Peroxide value

A discussion of what each test measures and why a specific test should be used is a presentation in itself, but additional information may be gleaned from Stier (6). It may be useful to bring in a qualified individual or organization from outside the organization to help establish a testing program and select a laboratory qualified to analyze oil and food samples. Many contract laboratories say they can conduct the tests described in the sidebar, but oftentimes they end up subcontracting the work. In addition, it is helpful to select a laboratory that can not only do the chemistry work, but can also explain what the data mean.

The oil testing schedule that is established should provide the operator with a means to properly evaluate oil changes over time. An example of a testing schedule might look like the following:

- Fresh oil
- Hot oil before frying
- Oil 0.5 hr after frying
- Oil 1, 2, 4, and 8 hr after frying
- Oil at end of shift
- Oil at end of day's operation
- Endpoint oil

After determining an endpoint marker, selecting the testing palette, establishing a sampling schedule, and setting up a means to evaluate product quality and shelf life throughout the study, the operator is ready to begin the study. Once started the operator must remain committed to the established goals. If processes, the products being produced, or anything else is changed, the baseline will be changed. Remember, the objective of the study is to determine the chemical, physical, and sensory parameters of oils and foods typical of normal frying operations and to utilize this data so changes to the frying system can be evaluated intelligently and without prejudice against the baseline.

### Putting the Baseline to Use

One of the basic tenets of running a business is continuous improvement. In fact, with the increased interest in food safety management systems such as the ISO 22000 standard and those that have been approved by the Global Food Safety Initiative (GFSI), continuous improvement is actually part of the standard or the audit scheme. One process that fryer operators at both the restaurant and industrial levels have utilized to improve operations is improved filtration or, more precisely, oil treatment. Years ago, Michael Blumenthal (1) proposed the terms "passive" and "active" filtration to differentiate filtration protocols that simply remove particulates from those that actually alter the chemistry of the oil. Today, people use the term "filtration" for a process that physically removes particulates and the term "treatment" (4) for one that adsorbs microcontaminants either physically or chemically. There are a number of potential benefits that oil treatment may impart to a frying operation, including

- Enhanced oil life
- Enhanced product quality
- Improved oil quality
- Reduced energy usage
- Reduced cleanup costs
- Enhanced operational efficiencies
- Improved food to oil ratio
- Improved kitchen operation
- Reduced waste oil
- Reduced disposal issues and potential costs

To evaluate an oil treatment system such as that illustrated in Figure 2, the processor compares the data collected during the baseline study with that of the oil treatment system. The same operating protocols must be followed, but the study may also be focused to meet the demands of the processor. For example, if product quality and shelf life are the elements that are most important to the processor, the oil testing program might emphasize those tests that are predictors of shelf life, such as hexanal, tocopherols, and soaps. When evaluating an oil treatment system, fryer operators need to be able to think "outside the box." Such systems are often designed to modify the oil in such a way that precursors of oil degradation reactions are removed or modified. Perhaps the greatest change in thinking is the industry attitude toward free fatty acids (FFAs). Many processors test FFAs in their frying oil because it is an easy and inexpensive test to perform. However, FFAs by themselves have no impact on the oil or the flavor of the fried food. In fact, it is possible to fry foods in 100% FFA mixtures. They are, however, more prone to oxidation reactions, which may create problems in foods and cooking oils. FFAs are also transient in frying oils since they will both volatilize and break down into other compounds.

**Fig. 2.** Filtrox oil treatment system (photo used with the permission of Filtercorp).

Unfortunately, very few processors have made the effort to establish a baseline for their fryer operations. To properly evaluate an oil treatment system, or any proposed change for that matter, the processor must conduct a baseline study. Without a baseline, the processor simply does not have the supporting data required to properly evaluate any process or system change, be it from a filter system to a treatment system, a change in product formulation or cooking oil, or a change in the food mix being fried. Any perceived improvements will be based on guesses, not facts, and given the competitive nature of the food business, guesses could well lead a company astray.

For those interested in learning more about frying there are several good resources, including *Frying Technology and Practices* (4).

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