Deep fat frying: science or art?

Deep fat frying is one of the most popular food preparation techniques in today’s world. Even though there are health issues, it remains a large and expanding industry. Fried products are enjoyed by consumers of all ages and in virtually all cultures because they are quick and easy to prepare and taste and smell good. Additionally, since frying is done at such high temperatures, fried foods are generally microbiologically safe and, depending on the type of product being manufactured, can be stored at ambient temperatures. This allows industrial processors to easily package fried foods whether they are snacks or coated products for storage and retail distribution.

Although the process itself appears relatively simple, deep fat frying is a dynamic process with many pitfalls that must be taken into consideration in order to produce high-quality tasty products that are attractive to consumers.

Deep fat frying is a very important part of the equation when it comes to producing high quality fried foods. Not only is the food fried in the oil but it is also taken up by the food, becoming a significant part of the end product. In recent years the selection of suitable frying oils has changed due to health concerns, decreased availability of vegetable oils suitable for frying and the placing of regulatory limitations on trans-fatty acid content in frying oils and fried food in Canada, the USA and some European countries. The end result is that many producers are looking for trans-free alternatives that have the high heat stability of trans-fats.

In addition, frying oils should be free of synthetic antioxidants or other additives such as dimethyldiphenylsiloxane (E900, antifoam) and should not be manufactured from sources that are genetically modified (GM). Finally, oils used for deep fat frying must be free from food allergens.

Since most oils used for industrial and restaurant frying are refined, bleached and deodorised, the oils will not contain allergens or GM organisms.

Today, there are several alternative oils with healthier fatty acid profile and product. Although the process itself appears relatively simple, deep fat frying is a dynamic process with many pitfalls that must be taken into consideration in order to produce high-quality tasty products that are attractive to consumers.

Minimising degradation

The heating of edible oils and fats results in both thermal and oxidative degradation of the frying oil. Fried foods such as potato chips have up to 40% oil that is absorbed during frying. Thus, it is extremely important to minimise the degree of oil degradation during frying to ensure the quality of fried foods. The composition of the fat in fried products has nearly the same composition as that of the used frying fat. Therefore, the quality of the frying oil will strongly affect the flavour, aroma, appearance, storage stability and content of potentially harmful degradation products in the fried product.

The minimisation of degradation during deep fat frying is a real challenge for the fryer operator with respect to the minimisation health risks. During frying, a constant formation of polar components from triacylglycerols can be observed. About 50% of the polar fraction (= total polar compounds) is oxidised monomeric triacylglycerols. These compounds are absorbed in the human stomach and intestinal tract due to their more hydrophilic property. Oxidised products may react with amino acid like lysine following the Maillard reaction. These advanced lipidoximation end products (ALE) and advanced glycation end products (AGE) have been shown to play an important role in the development and progression of different oxidative-based diseases including cardiovascular disease, diabetes and neurological disorders. Also the formation of heat-induced contaminants such as 3-MCPD-esters in fried fish products, heterocyclic aromatic amines in meat as well as acrylamide in French fries has to be taken into consideration. Therefore, it is important to optimise the frying process in order to minimise the potential for oil degradation and the formation of heat-induced degradation products.
POTATO CHIPS HAVE UP TO 40% OIL THAT IS ABSORBED during frying. A photograph (PHOTO: PAULISTA/DOLLARPHOTOCLUB.COM) shows the product. Finished product quality is a function of the frying process and the oil that is absorbed. Many phenomena such as the ineffectiveness of some antioxidants under frying conditions cannot be explained only by autoxidation. New mechanisms have to be discussed which might help to develop heat-stabilising agents based on natural sources and their role in optimising the frying process. It is especially important for industrial food producers to understand the different thermo-oxidative changes occurring in frying operations. The formation of undesirable oxidation products has to be avoided since it may result in the formation of off-flavours and shorten product shelf life, even in frozen foods.

To properly evaluate what happens in the deep-fat frying process and the suitability of vegetable oils or stabilising ingredients and additives used in deep fat frying, a systems approach to the process including detailed chemical analyses of the changing frying oil is essential. Utilising a single test, such as Rancimat, is not recommended since simply not enough information is provided.

Oil uptake and heat transfer

Studies show that, in general, only 20% of the total fat of a product being fried is absorbed during the frying process. The major part (80%) is taken up while food cools down. In this phase, a vacuum is formed in the capillaries of the crust that will suck the oil from the surface into the interior of the food. Therefore, it is important to understand the frying process and the impact of deep fat frying on the product. Finished product quality is a function of the frying process and the quality of the oil. Degraded oils contain higher levels of surfactant materials, which adversely affect heat transfer and ultimately the quality of the product.

The first seconds of the frying process are crucial for the development of flavour and textural characteristics of the fried food. These characteristics include crust formation and oil pick-up during the earlier cooling phase. The structural characteristics (porosity) directly affect the heat-mass transfer between oil and food. Heat energy is transferred from the oil to the food, while moisture is released from the food to the oil. Excessive temperatures may cause non-uniform crust with less, but larger pores, so that moisture is released in a rapid and uncontrolled way. If moisture release decreases too fast, the temperature in the boundary zone increases resulting in an increased rate of acrylamide formation. For instance, moderate temperatures at the beginning of deep fat frying encourage the development of a more structured crust through controlled heat-mass-transfer.

Analytics and quality assurance

Polar compounds and polymeric triacylglycerols are the most reliable chemical indicators for the assessment of used frying oils and fats. Other analytical criteria such as content of free fatty acids or anisidine value are not representative and the changes depend strongly on the type of oil. These analyses do, however, add to the overall understanding of the frying process. A more detailed analysis of the level of polar compounds, polymerised triacylglycerols, monomeric oxidised triacylglycerols and colour index helps to detect the critical points during the production of fried foods. In this context, Near Infrared Spectroscopy (NIR) is a valuable tool as this system rapidly provides all this information within a few seconds. Validated standard methods are available today. In fast food restaurants where the products are prepared for direct consumption, it is possible to monitor oil degradation by measurement of the dielectric constant which is related to the degree of degradation. Results are expressed using a value that roughly corresponds to the amount of polar material present in the frying oil. It is necessary to validate these quick tests with other validated standard methods. Be aware, however, that it is very difficult to implement and maintain a monitoring programme such as this in the restaurant environment.

Building the bottom line

Today, food processors and restaurant operators working in the area of fried food and suppliers to these industries – which includes oil producers, food and ingredient suppliers, equipment manufacturers and the service trade – must understand that the foods they manufacture or serve must not only be safe and wholesome, but also tasty and palatable, in order to remain in business. The pressure on the industry is great and the competition is tough, but understanding the science and technology of frying as well as the markets and demands is essential and helps to build the bottom line.

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