

3rd International Symposium on Deep Fat Frying

- Optimal Operation -

Abstracts

History of Deep-Fat Frying and Legal Regulations

Christian Gertz,

Chemisches Untersuchungsamt Hagen, Pappelstr. 1, D-58099 Hagen, Germany

Abstract

Frying means the cooking of food in hot, liquid fat. Similar to the cooking with hot water the heat transfer is managed exclusively by the hot, liquid medium. Frying processes are executed at temperatures between 140- 200 °C. far more than you can reach with boiling water, and less you need to roast food in a circulating hot airflow.

Everybody believes that deep-frying or pan-frying has its beginning in the early Fifties. But the history of frying food is an old one, if you regard the application of frying processes for the manufacturing and preparation of food.

The history of legal regulations started after a lot of laboratory and statistical work has been done. During the first symposium on deep-frying fats in 1973 the German Society of Fat Science (DGF) tried to define basic guidelines recommended for restaurants. Six years later, when the method of total polar materials (TPM) was proposed, the second DGF-symposium revised the recommendations introducing TPM as a new criterion.

Meanwhile a number of nations have published their own standards for frying fats and oils. These national regulations include criteria like acid value, polymer concentration, oxidized fatty acids or polar materials as well as physical dimensions like viscosity, colour and foam. But none of them can describe the rate of deterioration exactly. Nevertheless the DGF-method of polar materials is accepted as one of the best criteria and adopted by IUPAC and AOAC International.

But the history of deep-frying fats and oils is not yet finished as demonstrated by the new developments of quick tests and the idea of optimum frying.

Chemistry of Frying and Optimisation of Deep-Fat Fried Food Flavour

Richard F. Stier

Director, Technical Services, Agriculture Led Export Businesses

Abstract

Fried foods have been enjoyed by man for thousands of years. The main reason is that these foods have unique and delicious sensory characteristics. This is one of the reasons that fried foods and frying is so popular; the other being that hot oil is an excellent heat-transfer medium, so food cook quickly. Fried food quality and, hence, its sensory properties, are affected by a number of parameters including the type of oil and its chemistry or quality. Once operators begin frying, the quality of that oil begins to change, but the bottom line is that the sensory properties of the food are directly affected by the changes in oil quality. These changes and part of the focus of this presentation will be the surfactant theory of frying, which helps to explain why food fries.

Formation of cyclic fatty acids during the frying process

William W. Christie

Scottish Crop Research Institute (and Mylnefield Research Services Lipid Analysis Unit),
Invergowrie, Dundee (002 5DA), Scotland

Abstract

Cyclic fatty acids formed during frying were at one time thought to be highly toxic. Fears have receded somewhat, but this stimulated considerable research.

In our work, the structures of all the cyclic monomers formed from oleic, linoleic and linolenic acids in heated frying oils were determined. The compounds were first isolated by urea fractionation and reversed-phase high-performance liquid chromatography (HPLC). The mixtures were simplified by silver ion HPLC, and then examined by gas chromatography-mass spectrometry in the form of the picolinyl esters and 4,4-dimethyloxazoline derivatives. In addition, hydrogenation and deuteration aided the characterization. Assignment of ring and double bond configurations was accomplished by gas chromatography linked to Fourier-transform IR spectroscopy. Surprisingly a simpler range of compounds was formed from the trienoic acid than from the diene. Linolenic acid gave four basic cyclic diene structures (two with cyclopentene and two with cyclohexene rings), each of which existed as isomers with different double bond and ring conformations. Some bicyclic fatty acids were formed from linoleate. The mechanism of the reaction is believed to involve intramolecular rearrangements via free radical catalysis with traces of hydroperoxides as the initiators.

Health Aspects of Thermoxidized Frying Oils and Fats

Gerhard Billek
Hamburg, Germany

Abstract

Since 70 years and with considerable effort, more or less systematic investigations have been performed to answer the question if heated fats are detrimental to health. Early nutritional studies were based on severely overheated fats in which the amount of heat damage was not known. These experiments have been quite unrealistic since such fats are not consumed in the diet. However since that time the general opinion prevailed that heated fats and oils could be harmful.

It is more realistic to heat fats and oils in equipments for deep-fat frying under the conditions of good commercial practice and to feed them to test animals in long-term feeding trials. In some cases the heated fats and oils were separated into various fractions and these were fed individually. The results of the most significant long-term feeding trials are reported and critically evaluated. Certain fractions of the heated fats and oils, e.g. the so called "Polar Material" caused clearly noticeable effects in the feeding studies: growth retardation, increase in the weight of livers and kidneys, disorders of the enzyme system. Several researchers tried to trace the harmful compounds in these very complex mixtures of fat degradation products.

In the last years several research groups specialized in the use of cell cultures and enzymological methods and gained insight into absorption and metabolism. These techniques are useful if not enough material is available for feeding studies. Model compounds or model compound mixtures have been synthesized to overcome troubles with lack of material. However, in most cases their structures and/ or compositions deviated more or less from the genuine

compounds or fractions of the heated fats and the results of these studies must not be generalized.

New analytical procedures like a combination of column chromatography and high-performance size-exclusion chromatography allow to distinguish between various well defined fractions and quantitative data about their occurrence in heated fats are obtained:

- mono- and di-glycerides and free fatty acids, which are harmless being normal digestion products,
- dimeric and polymeric triglycerides and dimeric fatty acids, harmless as well because of very low absorption rates and
- oxidized triglyceride monomers, the source of saponification and degradation products like oxidized monomeric and dimeric acids, oxidized cyclic fatty acids and other polar compounds.

These oxidized compounds, most of them of unknown structures, are more or less detrimental to health and in any case nutritionally suspect. Care should be taken that they do not accumulate during too long frying operations and because of too high temperatures in the frying process. Several unsolved problems in this area will be discussed.

Application of near infrared spectroscopy (NIRS) to the analysis of frying fats

H. Büning-Pfaue, S. Kehraus, Bonn
University Bonn, Institute of food science and food chemistry
D-53115 Bonn, Germany

Abstract

Conventional analytical methods for determination of the degradation of deep-frying fats are highly time-consuming and labor-intensive. In addition large volumes of solvents are considered as environmentally problematic. These disadvantages are the reason for testing the technique of NIRS as a potential and alternative method for analyzing frying fats. This paper gives an introduction to the NIRS method development and assesses the feasibility of the NIRS optic probe technique for the measurement of deep frying fat samples.

Chemometric NIRS-methods are now widely accepted. They are used in numerous applications for qualitative and quantitative analyses in various fields, e.g. food, agriculture, medicine, chemicals, pharmaceuticals, polymers and cosmetics. Its popularity comes from its three major advantages as an analytical technique: speed, calculable accuracy and little sample preparation. Crucial to quantitative NIR spectroscopy is the performance of a calibration experiment. That means NIRS method development essentially uses chemometric analysis. First of all, for this development, the analytical data of a set of calibration samples has to be collected. These samples should contain all chemical variations to be expected in the unknown samples, which will be determined later.

The purpose of this calibration experiment is to establish a mathematical relationship between the NIR spectra and the chemical parameters of the analyzed sample set. Essential in determining these chemical parameters is an independent technique, the reference method. Once the mathematical model is established the analysis of the unknown sample can be performed. That means the prediction of their demanded chemical parameter results in the basis of the NIR spectra of these unknown samples.

This will reduce operator action to a minimum, enabling untrained personnel to do routine analyses. As a result, NIR-Spectroscopy gives the user the optimum flexibility while minimizing costs.

For this method development all samples of frying fats were from Dr. Gertz, Official Institute of Chemical Analysis, D-58093 Hagen, as were all reference data: acid values (AVs), total polar material (TPM), dimeric and polymeric

triglycerides (DPTG) and Food Oil Sensor values (FOS) were determined to estimate the degradation of the frying fats. The AVs and TPM were determined according to the DGF-methods, the DPTG according to the IUPAC method and the FOS values according to the method of the Northern Instrument Corp.

Thirty-eight samples of deep fried fat were spectrometrically analyzed. For the NIR measurements the spectra of temperature adjusted samples (water bath, 50°C) were collected by measuring the transflexion (2 mm) between 1000 - 2500 nm; 5 scans were done for every sample. The 2 m-fiber optic attachment was connected to the FT-spectrometer NIRVIS (Buehler, CH-Uzwil) and the software NIRCAL Vers. 2.0 was used. Different outlier detections took place. Samples were divided into calibration and validation sets in the ratio of 4:1; statistical analysis was carried out using MPLS algorithms and the first derivatives of $\log 1/R$.

Several statistical criteria were used to decide if the mathematical model is acceptable for predicting the demanded chemical parameters of the unknown samples:

The "Standard Error of Calibration" (SEC) and the "Standard Error of Prediction" (SEP) as estimates of calibration and validation procedures, the "Bias" as the average difference between measured and predicted values, and furthermore the calculated "Error of Top Ranges" (± 2 SEP; BIAS: no significance); further success in this method development was judged using the coefficients of determinations (R^2_{cal} and R^2_{val}), the SECV (Standard Error of Cross Validation) and the ratio of Standard Deviation of the original data (SD) to the SECV. SD/SECV-values of 2.5 – 3.0 are considered as adequate for screening purposes, but values of at least 3.0 – 5.0 are required for quality assurance.

High calibration accuracy (low SEC, SEP and SECV; high R^2 , SD/SECV ratio near 3.0 or higher) seem to be obtained for AV and FOS; the poorer calibration statistics for TPM and DPTG indicate that this NIRS model may be considered as adequate only for screening; but the high bias-values and the calculated Error of Top Ranges indicate that further work is required to include additional samples having a broader range of values for some of the measurements, before NIRS can be introduced into a control program for the degradation of deep frying fats. Improvement in accuracy may also be possible if some reference methods can be further developed particularly the TPM- and DPTG-reference methods (Table. 1 and 2).

Table 1

Statistical criteria results from NIRS method development for deep frying fats, fiber probe optic, FT-NIR-spectrometer Bühler NIRVIS/NIRCAL Vers. 2.0; MPLS-algorithms; calibration sets: 24 - 33 samples; validation sets: 5 - 9 samples

Table 1:

Statistical criteria results from NIRS method development for deep frying fats, fiber probe optic, FT-NIR-spectrometer Bühler NIRVIS/NIRCAL Ver. 2.0; MPLS algorithms; calibration sets: 24-33 samples; validation sets: 5-9 samples

Parameter	SEC [%]	R ² _{cal}	SEP[%]	BIAS [%]	Error of Top of Range[%]	R ² _{cal}
Acid Value	0.15	0.99	0.3	0.3	± 0.4	0.98
TPM	2.37	0.98	1.6	0.05	± 3.3	0.99
Di-Polymer TAG	0.91	0.98	1.3	0.2	± 2.6	0.98
Food Oil Sensor	0.3	0.99	0.3	0.15	± 0.6	0.98

Table 2:

Statistical criteria after cross validation, 39 samples of deep frying fat

Parameter	SD/SECV	SECV [%]	Error of Top of Range[%]
Acid Value	1.1/0.2 \cong 5	0.19	± 0.38
TPM	11.4/2.3 \cong 5	2.3	± 4.6
Di-Polymer TAG	7.6/1.05 \cong 7	1.05	± 2.1
Food Oil Sensor	1.6/0.3 \cong 5	0.31	± 0.6

Quick Tests for Used Frying Fats and Oils

Karin Schwarz

Institute of Human Nutrition and Food Science, Christian-Albrechts-Universität
Olshausenstr. 40, D-24098 Kiel, Germany

Abstract

Deep-frying is a popular and widespread way of food preparation. Due to the high temperature during deep-frying the fat degrades rapidly. The rate of degradation depends on several parameters such as the type of fat, the fried food, and the frying conditions. Thus, it is not possible to suggest a general period of usage until the spoilage of the deep-frying fat begins and the fat has to be changed. Therefore, simple criteria for the evaluation of the quality of the fat are necessary. Quick tests are a way of estimating the quality of deep-frying fats on a standardized basis in small food institutes. Several quick tests have been developed based on physical parameters (viscosity, dielectric changes) and on chemical parameters (free fatty acids, oxidized and polar compounds). The test kits consists of portable instruments or simple colour reaction sticks with a color scale. Test kits available on the German market in the 90s were compared with laboratory methods for the evaluation of used deep frying fats. The results of a questionnaire will be presented which gives an overview on quality control for used deep-frying fats in small food institutes today.

Electronic Nose for Detection the Deterioration of Frying Fat — Comparative Studies for a New Quick Test

Ulrich Demisch, Mike Muhl, Testo GmbH & Co, Lenzkirch, Germany

Abstract

The organoleptic analysis of frying fats has been one of the standard methods for determining the quality of frying fats and oils, in spite of the well-known disadvantages. Following the recommendations of the German Society of Fat Science (Deutsche Gesellschaft für Fettwissenschaft, DGF), the more objective chromatographic determination of polar components has become more and more important in the last years. Today a frying fat or oil is considered to be spoiled, if the level of polar materials exceeds 24% or 27%, depending upon the country, and if confirmed by the organoleptic impression.

However, a suitable device compatible with standard methods for an site measurements is not yet available. In a study we tested the feasibility of a new frying oil tester based on an electronic nose, compared to the measurement of the dielectric constant.

As is known, the dielectric constant is a good measure of the level of polar components in a frying oil. This has been proven in numerous investigations with the Food Oil Sensor (FOS) from the Northern Instruments Corporation. Known disadvantages of the device are:

- . high purchasing cost
- . necessary adjustment with reference substances
- . insufficient assessment of the measured results by the device
- . necessary cooling of the frying oil before measuring
- . strong influence of the water level of the oil
- . necessary filtration for accurate results
- . sensitivity in doubt ?

Our aim is to produce a considerably lower priced device with improvements on the above mentioned characteristics.

Our electronic nose is intended to determine the degree of fat spoilage by measuring directly above the fat surface. We set up laboratory samples which are able to observe the ageing of the frying fat. The results were compared to FOS values. Neither the nature of used frying fat nor the fried food had any relevant influence on the results from the electronic nose and the results were in keeping with those of FOS. The temperature of the fat should ideally be between 140 and 180 °C.

We had different metal oxide sensors of various manufacturers under consideration. As it turned out, only few sensors are in anyway suitable for this application. Most of them became clogged up, in spite of their much higher internal working temperature. As a consequence they are destroyed after a short working time. Only few sensor types had the necessary selectivity to the substances which play a major role in recognising the ageing of fat in volatiles. A further challenge is the strongly fluctuating moisture in the fat volatiles, caused by water from fried foods. All metal oxide sensors are more or less cross-sensitive to moisture. Therefore moisture compensation is imperative for measurements taken directly after the frying procedure.

The results of various measurements will be shown. However, at this stage they are not sufficiently suitable for setting up a practical measuring system.

A universal, easy to use, and direct method for measuring % total polar compounds in degrading oils

Jack G. Truong, 3M Company, Paris, FRANCE

Abstract

When oils such as fats and shortenings are heated in the presence of air (oxygen) and water, thermolytic and oxidative reactions take place, resulting in the degradation of the oils. Oxidation generates new functional groups in the hydrocarbon chain of the triglycerides and hydrolysis generates free fatty acids, monoglycerides, diglycerides, etc.. In addition, when different foods are used in the same vat of oils, different amounts of polar compound species are generated depending types of foods used.

It is known in literature that oils containing high amount of % polar compounds would produce fried foods with less than desirable taste and more recently with the HACCP regulations in place, several European countries have set the maximum upper limit of % polar compounds to be at 25 – 27 %.

Heretofore, there exists only one direct and accurate method (the official ISO 8420) for determination of total percentage of polar compounds in oils. However, this method takes a long time for measurements and it requires operators to have sufficient scientific skill sets and to operate in laboratory settings.

In this paper, we will disclose for the first time an innovative method and system of measuring the % total polar compounds in degrading oils that

- is easy to use, quick, and simple
- can measure % polar compounds directly and is independent of types of oils used, types of food fried, mixtures of foods, oils, etc..
- is reproducible and reliable
- does not contain chemicals nor require it to be in contact with the oil vats

We will discuss the science and technologies of our system. We will then review the comparative data using our method vs. what are available in the market and correlation with the ISO 8420 method. We will also provide examples of how this new 3M system can help restaurants, oil suppliers monitor their product quality, conform to regulations, etc...

Chemical and Physical Parameters as a Quality Indicator of Used Frying Fats

Christian Gertz

Chemisches Untersuchungsamt Hagen, Pappelstr. 1, D-58099 Hagen, Germany

Abstract

Fats and oils, used for preparation of foods, are exposed to elevated temperatures in presence of water and oxygen causing chemical changes. The degree of deterioration depends on the nature of the frying oil and many other circumstances such as construction of fryer, the kind of food, etc. Consequently, the frying-process must be seen as a complex system depending on the extent of chemical reactions like oxidation, polymerization and hydrolysis where the physical and chemical properties of the frying fat always alter.

To cover the physical properties and chemical changes of frying fats many methods are proposed in literature. Physical methods include density, viscosity, smoke point, colour, refractive index, UV absorption, infrared spectroscopy and dielectric constant. Chemical tests are the determination of free fatty acids (acid value), iodine value, anisidine index, saponification value, non-oxidised monomer fatty acids, polymerised triglycerides, petroleum ether insoluble fatty acids and total polar compounds.

Among all these analytical criteria the determination of total polar materials by column chromatography is considered to be the most reliable method to monitor continuously the alternation of fats and oils during the frying process. Quick tests give only information about the point of discarding. But optimal operation in frying means controlling the frying process and to keep the optimum concentration of deterioration products to have good flavour or producing crisps with good shelf life.

But the determination of polar materials is too time consuming and laborious. The quality control in the production (HACCP) of fried food as well as the health food inspection demands a simple procedure, using no chemicals, easy to use, where the results correspond to official methods like polar compounds.

Therefore, among all the physical and chemical methods the determination of polar materials, polymerised triglycerides by GPC and acid value were selected to be compared with the results of the measurements of the dielectric constant (Food-Oil-Sensor) and the relative viscosity (Fri-Check®).

More than 150 samples taken in commerce by the food inspection were analyzed. The analytical data were statistically evaluated and gave good correlation of the physical methods with the chemical criteria.

Chromatographic Methods for Evaluation of Used Frying Fats and Oils

Erhard Schulte

University of Münster, Institute of Food Chemistry Münster, Germany

Abstract

Only two chromatographic methods are applied in practice for the separation of artifacts in used deep-frying fats, the HP-GPC (HP-SEC) for the determination of oligomerized triglycerides and the column chromatography (CC) for the determination of polar compounds. We were able to improve the separation of HP-GPC by using two columns in series with dichloromethane as mobile phase, however only some more shoulders appeared. They could not be quantified and so we did not try their identification. The prolonged retention times and the larger consumption of eluant are unfavourable in routine.

The column-chromatographic separation of polar and apolar constituents needs large amounts of adsorbent and solvents and is too time-consuming for routine analysis. So we tried to avoid these disadvantages using TLC on HPTLC plates with densitometric quantification and TLC on Chromarods with FID-quantification (Jatroscan). Both techniques gave totally useless quantitative results. Also the trial to sub-fractionate the polar compounds into defined classes by improving the separation did not seem promising for routine because of the extremely complex composition.

We substituted the large CC-glass column for a small SPE cartridge and miniaturized this method. About 100 mg of oil or melted fat is directly weighed on top of the SPE-column containing 1 g of silica deactivated with 5 % water. The fat is dissolved in 1 ml of 2-chloropropane (isopropyl chloride) and the apolar constituents ("normal triglycerides") together with small amounts of apolar material, e.g. hydrocarbons, sterols and wax esters) are eluted with 10 ml of the same solvent. After evaporating the solvent the residue is weighed.

The advantage of this simple procedure over the classical CC are:

- using "ready for use" micro-columns without packing or conditioning
- weighing and dissolving the samples directly on column
- requiring small amounts of adsorbent and solvent with the possibility to reuse the evaporated and condensed solvent
- shorter time for elution

- clear separation of polar and apolar constituents because of the higher selectivity of the eluent and the smaller particle size of adsorbent.

Two advantages over the GPC are the simple equipment and the immediate use.

In spite of these advantages the results seem to be a little higher in average than with the classical CC, obviously because the apolar oligomers are not eluted together with the other apolar constituents. Virtually this is desirable because of the original aim of the method, to determine all artifacts. If this is not desired for a better comparability with the results of classical CC, the eluent mixture used there way also be used for SPE (micro SPE). So the micro-CC regains on GPC economically.

Another outlook for determining artifacts is the derivatisation of carbonyl groups to their 2,4-dinitrophenylhydrazones. These can be separated by RP-HPLC and selectivity detected in the UV.

Quality Criteria of Industrial Frying Oils and Fats

Bernd Brinkmann

Walter Rau Neusser Öl und Fett AG, Industriestr. 36-40,
D-41460 Neuss, Germany

Abstract

Fried food is very popular all around the world and comprises a wide variety of different products. The chemical composition of oils and fats determines clearly their functionality. Since the shortenings become part of the fried products, factors like the melting point and the solid fat content may contribute a lot to the palatability and appearance of fried food. Major types of products and quality issues in relation to the frying shortening used for their production are described and discussed.

Interactions between Fat and Food During Deep-Frying

M. Carmen Dobarganes, G.Márquez-Ruiz and J.Velasco
Instituto de la Grasa. Avda. Padre García Tejero, 4.- 41012 Sevilla (Spain)

Abstract

The complex reactions taking place under the conditions of the frying process have been extensively studied in frying oils. Nevertheless, the great importance of maintaining the quality of used frying oils and fats is mainly due to the absorption of used frying oils in the fried foods being ingested.

In this presentation physical and chemical interactions between food and used frying oils will be considered. On one hand, the main variables in the food and used frying fat influencing fat uptake and water loss will be defined. Also, results obtained by application of modern analytical techniques evaluating total polar compounds, polymeric compounds, oxidised compounds, diacylglycerols and fatty acids will be commented to establish differences between the used frying oils and the oil absorbed in the food during the preparation of non-lipidic foods.

On the other hand, interchanges between food lipids and used frying oils during preparation of fatty foods -including migration of triacylglycerols, pigments and phospholipids as the most important groups of compounds- will be considered. Due to the exponential increase in the production of frozen pre-fried foods, normally subjected to a second frying operation before consumption, special attention will be paid to the interactions between the two used frying fats or oils involved.

Finally, chemical interactions between polar compounds from both the food and the used frying fat or oil contributing to formation of new compounds will be commented in detail.

In general, results indicate that, from a quantitative point of view, there are no significant differences between the used frying fat in the fryer and that absorbed into the food. Although selective adsorption of polar compounds on the food surface was not found, interactions taking place during frying between amino acids or proteins and specific functional groups in oxidation compounds formed in the oil have been reported for different foods along with their contribution to changes of nutritional or sensory significance.

**Deep-fat frying of food:
Transfer (heat and mass), transformations and reactions inside the
material**

Olivier Vitrac^{1&2}, Gilles Trystram² and Anne-Lucie Raoult-Wack¹

¹*ENSIA. Food Process Engineering Department, 1 Av. des Olympiades. 91744 Massy cedex. France.*

²*CJRAD-AMIS-PAA, B.P. 5035, 34398 Montpellier cedex 5, France.*

ABSTRACT

Deep-fat or pan frying have been used for many centuries to cook meat, fish and vegetables. Fried products are popular foods all around the world whatever the culture, the consumer age or the time of the day, because of their unique flavor and crispy texture. However, fried foods are now more and more alleged to be exposing the consumer to excess weight, toxicologic or mutagenic effects, due to the success of both industrial and food-service products. Many studies have been conducted to elucidate the complex mechanisms of fats decomposition at high temperature and to assess their effects on human health. In comparison much less work has been done to understand how food materials fry. And yet, further knowledge of the phenomena occurring during frying and cooling inside the material is essential to control quality and safety of fried products, and to develop new applications of frying to products.

Materials subjected to frying undergo intense drying, generally accompanied with structural changes (formation of pores and crust), as well as physicochemical, biochemical reactions (colour and flavour changes, loss of vitamins, fats or solutes, starch and/ or protein modifications) and microbiological inactivation. Therefore, frying can be considered both as a very efficient drying method, and a multifunction process, which makes it possible to combine in one single operation, various treatments including dehydration, texturisation, cooking, roasting, and direct formulation of food materials. These treatments modify the nutritional, organoleptic and functional properties of the product, and their suitability to complementary processing and storage.

The aim of this paper is to show how the application of process engineering methods have recently brought further understanding of basic principles and mechanisms involved at different scales and different times (pretreatment, frying and cooling) during deep-fat frying:

- at oil cooker scale how heat is transferred to the wet and cold material ?
- at material scale how water is based and goes out of the material ?

- at microstructure scale which are the consequences of inner stresses, intense drying and heating on microstructure and on oil migration in the porous matrix?
- at molecular scale which are the interactions between the polymers of the solid matrix and or compounds or steam ?, which are the consequences of transport properties (permeabilities...)?

The recent results concerning the understanding of frying process were obtained from, thanks to the large breakthroughs in on line instrumentation (sensors for heat and steam fluxes, local overpressure), methodology for micro-structural and imaging analysis (NMR, MRI, ESEM), computer simulation tools of coupled transfer and transport phenomena.

These recent advances have opened up the way to

- a large database of the behaviour of various materials during frying with qualitative (structure, deformations, transport and transfer mechanisms) and quantitative (mechanical, transport, thermophysical properties changes) data;
- the development of new tools to control frying operations via final product quality in real conditions (real foods, variable raw materials, and dynamic control)
- the design of new flow charts, or products, including or using the frying unit operation
 - i) chocolate processing including a fry-roasting step,
 - ii) oil extraction process of avocado including a fry-drying-texturisation step,
 - iii) production of dried fruits by vacuum fry-drying-formulation, iv) treatment of timber to increase its natural durability.

However, simultaneously improving food formulation, process control of such a complex operation for high quality products or new applications of frying require further research into methodologies, tools and strategies. A possible future in deep-fat frying would involve an increasing interdisciplinary collaboration with food chemists, engineers, toxicologists, nutritionists, material scientists as well as catering and industrial sectors. Indeed, such a scheme requires to take into account a large number of parameters which only a systemic, interdisciplinary and comprehensive approach will integrate.

Stabilisation of Frying Oils With Natural Antioxidative Components

S. Parkash Kochhar

Good-Fry International nv, 48 Chiltern Crescent, Reading RG6 1AN, ENGLAND

Abstract

Deep fat frying is a complex, thermal chemical process that produces fried foods with desirable colour, appearance, flavour, and texture. Normally, less stable liquid oils are hydrogenated to enhance their oxidative stability for deep-fat frying purpose. However, considerable amounts of trans and positional isomer fatty acids are formed during hydrogenation, which are nutritionally undesirable. The stability of frying oils is sometimes increased by careful blending of polyunsaturated oils with more saturated oils. The natural way of improving oxidative and flavour stability of frying oils and fats is by adding natural antioxidative components and precursors present in the plant kingdom, such as 'virgin' olive oil, sesame seed oil (SSO), rice bran oil (RBO).

A variety of natural antioxidative components, present in these oils, comprise tocopherols and tocotrienols, special sterols e.g. delta5-avenasterol and sterol esters, squalene, sesamol, sesaminol and related compounds, polyphenols, etc. Various antioxidative components present in SSO and RBO are largely retained in Good-Fry® Constituents, GFC, manufactured according to European patent and USA & worldwide patent applications pending (Silkeberg & Kochhar, 1998).

Generally, palm olein, palm oil, partly hydrogenated rapeseed oil / soybean oil and / or their blends are mainly used by the frying industry for the production of a variety of snack products and pre-fried convenience foods. Several new frying oils with good oxidative stability, which do not require hydrogenation, are now commercially available in the European market, for example, high-oleic sunflower seed oil stabilised with GFC. The results showed that the addition of 6% GFC to unhydrogenated rapeseed provided crisps, produced on industrial scale, with stability similar to those fried in palm olein without GFC. Shelf life of crisps fried in soybean oil, iodine value 130 was substantially increased by addition of 5% GFC. The Good-Fry Constituent can also be added, with advantages of flavour stability of fried snacks, to oils such as palm oil or palm olein at lower level 2% . It is forecasted, to meet an ever-growing consumer demand of "healthier" snack products, the usage of natural antioxidative components in stabilising frying oils rich in MUFA will grow tremendously.

Evaluation of Stability of Fats at Elevated Temperature

Karin Schwarz

Institute of Human Nutrition and Food Science, Christian-Albrechts-Universität,
Olshausenstr. 40, D-24098 Kiel, Germany

Abstract

The stability of fats during frying is of high importance in order to produce safe and high quality food. Therefore, it is of interest to compare parameters of the fresh fat with the stability under frying conditions. The frying stability of several commercial frying fats of different consistency was tested during the preparation of French fries. The oil degradation was tested by measuring the dielectric changes of the fat with the Food Oil Sensor (FOS). The frying stability was expressed as the time until the fat reached a FOS value of "3.0". A FOS value of "3.0" value corresponds to 15-16 % polar compounds when calibrating the instrument with the FOS test fluid corresponding to "0" value. The results were compared with the fatty acid composition, peroxide value, smoking point, melting point and iodine value of the fresh fat. In addition, the stability of fats under frying conditions was compared with the stability under elevated temperature and in the Rancimat test.

Poster

Testing and Comparing Oxidative Stability of Vegetable Oils and Fats at Simulated Frying Temperature

Christian Gertz, S.Parkash Kochhar, S. Klostermann
Chem. Untersuchungsamt Hagen, Germany, Good-Fry Int. n.v. R&D, Reading, UK

Abstract

The chemistry of vegetable oils at frying temperatures is more complex than just thermal oxidation or autoxidation. Initially the oil undergoes autoxidation, followed by thermal oxidation and reactions like hydrolysis, polymerisation and dehydration at above 150°. The known methods like swift-test (Rancimat) are normally executed at lower temperatures by bubbling a stream of air. To estimate the stabilising activity of synthetic and natural food additives at frying temperature a new method has been used.

Non-refined and refined vegetable fats and oils were heated at a temperature of 170 °C after adding water-conditioned silica gel, for two hours. The degraded products were measured to assess the oil stability at frying temperature.

The determination of polymeric triglycerides by size exclusion HPLC was carried out for the estimation of the oxidative heat stability of vegetable fats and oils.

The obtained results of more than 20 different samples show that the stability of the vegetable oils at frying temperature could not only be explained by the fatty acid composition.

There is an evidence which supports co-relationship between the unsaponifiable matter content and oxidative stability. Corn oil was more stable than soybean oil and, rape seed oil better than olive oil. It was also observed that non refined oils proved to have a better stability at elevated temperature than refined oils.

Tocopherols, various tocopherol esters and lecithins, phytosterol fractions, phenolic compounds like quercetin, oryzanol, ferulic acid, squalene, BHT, BHA and other compounds like ascorbic acid 6-palmitate, gallates are added to refined sunflower and rape seed oil and their effectiveness has been investigated.

Both linoleic and oleic rich oils gave comparable results for the activity of the various compounds. Alpha tocopherol, tocopherol esters and BHA have low or negative effects at frying temperature. Ascorbic acid 6-palmitate and some phytosterol fractions were found to be the most antioxidative compounds.

A New Stabilizer Product to Optimize Oil Management for Restaurant and Fast Food Fryers

Bernard Friedman,

MirOil Division of Oil Process Systems Inc., Allentown, US

Abstract

Polar degradation substances form in the oil all the time the fryer is on. Many of the degradation substances are recognized as potentially serious health hazards when they accumulate in the oil. The oil's cooking performance is undermined. Periodic discard of the oil is required because either the sensory quality of food is unacceptable or the oil contains high levels of unhealthy degradation substances, or both.

Frying fats and oils have a finite and relatively short useful life with traditional oil management procedures. The sensory quality of the food diminishes each hour and each day the oil is used. The degradation rate is affected to only a small degree by the presence of antioxidants or traditional filtering with inert or noninert treatment.

This report introduces an oil management program for use with an anti oxidant oil and fat stabilizer to provide truly "optimum" frying. In this scenario the food quality is always good or excellent because the food is cooked in oil that is always good. The polar content is always within regulatory limits. Fryer surfaces are always free of carbon and polymer gum deposits.