PO Box 259, Beckenham, BR3 3YA
Tel: 020 8776 2644 Fax: 020 8249 5402
lynda.simmons@neoda.org.uk
www.neoda.org.uk

NATIONAL EDIBLE OIL DISTRIBUTORS ASSOCIATION

FRYING GUIDELINES

1. Introduction

Deep frying is a most useful method of cooking food for four main reasons:

1 It is a fast;
2 Because of the short cooking period, it is possible to prepare food as it is required thereby keeping waste is kept to a minimum;
3 In deep frying, the food is immersed in a very hot material which sears and seals the food, keeping in more flavour then by many other methods of cooking;
4 The layer of fat or oil deposited on the food during frying improves the eating quality of the food. Frying also imparts a characteristic flavour which is different to that obtained by other methods of cooking.

Oils and fats are expensive and they are worth looking after carefully if they are to give a long and economic frying life. These guidelines set out the basic rules and principles of the process.

2. General Rules of Frying

1 Never heat the oil above 205°C (400°F) or it will spoil more rapidly. Use a thermostat or thermometer and regularly check them for accuracy, regulate the temperature of the oil as carefully as possible, avoiding hot spots and high flames. Frying at too low temperatures will result in greasy products and an excessive absorption of fat by the food. For further details see section 3.

2 Fry the food in the correct amount of oil. The general rule for batch fryers is to fry one part of food in six parts of oil. If too much food is immersed, the temperature of the oil will drop and the food will be greasy. If too little food is immersed, the amount of fat needed to top up the fryer becomes small and the main bulk of the oil will spoil more rapidly. For further details, see section 3 and section 5.

3 Choose the right medium for the job and use it properly. Solid fats should be treated more carefully during melting down and during topping up. Temperatures should not exceed 132°C (270°F) during the melting down of solid fats. Once melted, the fat can be heated to normal frying temperature. For further details, see section 6.
4 Prepare the food carefully, ensuring that it is as dry as possible before frying. Wet foods – particularly potatoes – tend to make the oil froth and break down and this is unsafe and wasteful. Fragile foods must be handled carefully to avoid break-up during frying. If a potato whitener is used, the manufacturer's instructions should be followed. For further details see section 4.

5 Clean the oil regularly by filtering at the end of each day to remove the small pieces of charred food which might accumulate. Clean the equipment by scrubbing with soap and water once a week.

Rinse away any soap or detergent used in cleaning. Do not use iron, or copper utensils as these metals can accelerate the breakdown of oil. For further details see section 8.

3. Temperature Control

Accurate control of temperature is essential and is best achieved by the use of a thermostat or by the regular use of a thermometer. It is also important to check the accuracy of the thermostat and thermometers themselves from time to time and to ensure that any instrument used is kept clean. In purchasing a thermometer, remember that the temperature to be measured will be high and probably at least 205°C (400°F) at times. Ensure that the instrument purchased is rated for use at these high temperatures.

An automatic cut out which comes into operation at a temperature above normal frying temperature and well below the flash point of the frying medium (see Section 16), is useful as a safety precaution.

Heating a fat or oil to the normal frying temperature of 191°C (375°F) greatly increases its tendency to spoil and is one of the most important factors governing the life of oil. The higher the temperature, the quicker the oil will deteriorate. On frying equipment where gas flames are used, the flame must be adjusted so that it does not flare up round the sides of the frying vessel and never to a height above the surface of the oil, because of the danger of fire. Hotspots are also dangerous and should be corrected.

As well as speeding up the breakdown of the frying medium, frying at too high a temperature will result in food which is darkly coloured – or charred on the outside before the inside is properly cooked.

If the frying temperature is too low, the resulting product will be greasy because the surface of the food is not sealed rapidly enough on entering the frying medium. Low temperature frying will also result in excessive absorption of fat by the food.

An important factor when considering the frying temperature is the relative amount of frying medium to the food being fried. When too small a quantity of oil is used, the sudden introduction of an excessive amount of food – at room temperature or below – will result in a large drop in temperature and the appearance of faults associated with low temperature frying. This is even more important in the case of frozen foods; for example, falls of temperatures of 18-28°C (30-35°F) can occur when frozen fish pieces are immersed in hot oil. On the other hand, when too large a quantity of oil is used, only a small proportion of it will be lost by absorption. Only a low rate of 'topping up' is then required and because regular topping up with fresh oil tends to damp down the rate of spoilage, the bulk of the oil in the fryer can deteriorate more rapidly.

As a general rule, one part of food should be fried in six parts of oil or fat.

4. Preparation of Food

All food to be deep dried should be as dry as possible before immersion in hot oil. If foods – particularly potatoes – are fried too wet, there will be a tendency for the oil to froth and break down. As a result the oil will have a shorter life and frothing oil is dangerous. Fragile foods and foods with loose coatings must be handled carefully to avoid break-up during frying and the accumulation of charred material at the bottom of the kettle. The accumulation of material can accelerate fat spoilage.

Chips and other potato products are often prepared in advance of requirements. It is well known that potatoes discolour under these circumstances. There are several preparations on the market which stop this discolouration. Care should be taken not to use solutions which are too strong. Soaking for too long or neglecting to drain carefully after treatment also tends to discolour frying oil more rapidly.

Do not add salt to the food before frying. If salt accumulates within the fryer, the oil will deteriorate prematurely (see Section 12).

Specific foods are discussed in Section 9.

5. Fat Absorption and Topping up

Most operators top up the fryer from time to time. As a general guide the fat absorption of potato chips is usually 5-6%. That is, 10 kg of potato chips will pick up about 500-600g of fat during frying. More porous foods such as doughnuts will absorb more fat than this and figures of up to 30% have been recorded,

Fat absorption depends upon the time of frying (the longer the frying period, the greater the absorption), the total surface area of the food (the greater the area, the more absorption), the type of food surface (rough or porous surfaces absorb more fat), the frying temperature (the lower the temperature, the greater the absorption), the nature of the food and the nature and condition of the fat.

The general procedure in frying is to top up the fat as required. To some extent, the natural spoilage of the fat by heat is controlled or damped down by this process of continually adding fresh fat to the fryer. It is important to use the optimum amount of fat for the weight of the food being fried as this results in the best rate of topping up. For this reason, it is wise to reduce the number of fryers in use when trade is less brisk.

It has been said that if at least 20% of the fat is replaced daily, the frying medium is much less likely to require changing.

Nowadays with the use of blanched chips being more popular, top up rates are lowered and frying life extended due to the incorporation of blanching oil into the frying medium.

6. Choice of Frying Medium

Due to the nature of their composition, some oils and fats tend to be more sensitive to heat and spoil more rapidly, than others. It is therefore safer to use the fats and oils which have been specifically designed and processed for the purpose of frying.

There is a wide range of frying media on the market, and the ones which are available can be divided into three groups, depending on their appearance at room temperature:-

1 Solid – palm oil, lard, dripping, proprietary brands;
2 Liquid – groundnut oil, soyabean oil, rapeseed oil, corn oil etc. and blends of liquid oil and proprietary brands;
3 Fluid – proprietary brands.

Solid frying fats are generally very stable if they have been refined and stored properly. An exception is unrefined dripping which is more sensitive to heat and which is generally used at frying temperatures which are lower than normal.

Solid frying fats have to be dug out of the carton and the correct procedure is to melt them out gently (at temperatures not exceeding 132°C (270°F) before heating to frying temperature. Otherwise, they might burn before they melt. Many operators ignore this precaution, and frying life can be reduced as a result, despite the intrinsic stability of the material.

Liquid oils are easier to handle and use because they can be poured. The most stable liquid oils – groundnut and corn oils, for example – are generally the most expensive. Other oils and blends of oils are more economical, but rather less stable chemically.

Fluid frying media can offer the best of both worlds. They are pourable and do not need special melting before heating to frying temperature. They are generally more stable than normal vegetable oil blends. This improved stability, and the longer frying life which this entails, is brought about by additional processing during the production of the frying medium.

Price, stability and flavour (lack of off-flavour) are other considerations when choosing oil. Frying media often contain other materials, the most important being antioxidants and antifoaming agents or silicones. Antioxidants improve the storage life by suppressing spoilage by oxidation, and antifoaming agents extend frying life in batch fryers by controlling foaming.

It is useful to choose the frying medium to fit the food being fried and the busy-ness of the frying cycle. It has already been mentioned that regular topping up can damp down the rate of spoilage. If the food has a very low rate of fat absorption, or if the frying process is not busy, it is a definite advantage to choose from the most stable media. If the food has a high rate of absorption, fat spoilage is more likely to be controlled by continuous topping up with fresh fat or oil. In this case there may be less need to use a long-life frying medium.

7. <u>The Spoilage of Fats and Oils</u>

As a fat or oil is used for frying, certain changes take place which are mainly caused by the effect of high temperature in the presence of air and water. The oil becomes darker in colour and more viscous. It will tend to froth particularly when wet foods are fried in it, smoke is more readily formed. Surfaces of the frying vessel become coated with a brown resinous material which is difficult to remove. Fried food becomes more discoloured and patchy in colour, and it begins to possess a poorer flavour and a greasier texture. Off odours will begin to be noticeable.

These are all caused by the natural deterioration of the oil. By the time a frying medium is discarded, probably about one fifth of it will have been altered by these breakdown processes. The frying life of oil will depend on the nature of the oil being used and on the way in which it has been treated.

Apart from the normal precautions which have been mentioned in Section 2, the rate of breakdown of oil will depend upon its exposure to the oxygen in the air. It is, therefore, dependent on the surface area of the oil exposed to air and to a certain extent the steam which is given off from the food during frying tends to blanket the oil from oxygen. This suggests that it is better to keep the oil busily frying food for as long as possible. Oil held at frying temperature but standing idle is more likely to deteriorate.

Many metals, notoriously copper, (and its alloys such as brass) and iron tend to accelerate the breakdown of fat. Some types of thermometer are made of brass, and often drainage taps and 'home-made' pieces of equipment including strainers, ladles and containers, are made from the wrong metal. These should all be avoided.

A fuller discussion of the nature of oils and their spoilage is given in the second part of this brochure.

8. <u>Cleaning</u>

Once oil begins to deteriorate as a result of heating, the products which are formed tend to promote further deterioration and a sort of chain reaction is set up. A good system of cleaning should be in operation to help control this, and this implies the regular cleaning of both oil and equipment.

The oil itself should be cleaned at the end of each day's run by passing it through a fine mesh strainer to remove particles of food. If left in the fryer, these particles will char; accelerating decomposition and producing smoke and off flavours. A stainless steel mesh is preferable to one made of copper or iron, as mentioned earlier. If a very fine mesh or filter paper or filter cloth is used to strain the frying medium it must be remembered that a fat which is solid at room temperature will tend to set up – and block the strainer – as it cools.

The equipment must be emptied and cleaned at least once a week, to avoid the build-up of brown resinous material which is a natural breakdown product of oil. Cleaning should be effected by scrubbing with hot water and soap or detergent. Care must be taken where electric elements are located inside a fryer, partly to ensure they are thoroughly clean, and partly to avoid corrosion. Whatever soap or detergent is used it must be thoroughly rinsed away because soap and alkaline materials greatly promote the breakdown of oil. Also, if a fryer is not properly rinsed after cleaning, the fresh oil will already form a thin layer of fine foam on melting or initial heating (see Section 13).

If the equipment is fitted with a fat trap, ensure that it is regularly cleaned to avoid odours and fire hazards. For the same reasons, regular attention should be paid to extractor hoods and ducts.

9. Frying Specific Foods

Doughnuts - it has already been mentioned that doughnuts absorb up to 30% of fat during frying and therefore the fat used for frying doughnuts discolours and smokes more readily than fat used for frying potato chips. However, because of the higher rate of absorption, the frying medium is 'turned over' at a greater rate. It is necessary to be particularly careful when frying doughnuts. For example, it is preferable to rest or prove the doughnuts on greased, rather than floured, surfaces because the flour will tend to fall off into the frying fat and char.

In chemically raised doughnuts, it appears that increased fat and increased sugar in the recipe both result in more fat being absorbed during frying. The greater the surface area, the greater the absorption; cracks and rough surfaces increase the area, and finger shapes and rings have more surface area than spheres. There is also evidence that fat absorption is decreased by warmer ingredients, longer mixing times and stronger flours, although each of these may also result in poorer eating qualities. It is also advisable to experiment before adopting a new method.

Unless automatic equipment is being used, it is not easy to handle fully proved pieces of dough without damaging the structure. The dough can be transferred to the fryer by means of an oiled palette knife and the finger tips. Yeast raised doughnuts should be placed in the frying medium upside-down; this avoids the instability of the doughnuts during the second half of the frying process, after they have been turned over.

Many types of doughnuts are sugared after frying. For this reason, it is preferable to use a solid fat, because sugar adhesion is better and the sugar does not discolour so readily. The flavour of the doughnuts can be improved by adding a small quantity of cinnamon or mixed spice to the sugar. The doughnuts should be allowed to cool before sugaring, to prevent the formation of a wet, sodden coating caused by the steam escaping from the doughnut during cooling. The sugar in which doughnuts are rolled will pick up a quantity of fat; in bakeries, this sugar should be kept separate because some confectionary products, notably meringues, will suffer if fatty sugar is used.

Frozen Fish - when frying frozen fish, the main point to bear in mind is that the sudden immersion of very cold material into frying oil is likely to reduce the temperature considerably. The effect of this will depend on the type of frying equipment used. In automatically controlled fast recovery kettles, the temperature of the oils will return quickly to the correct point while the food is being fried. In slower kettles and ones which are controlled by hand, the frying temperatures may not recover in time and allowances must therefore be made when setting the temperature of the oil before the food is introduced.

Above 191°C (375°F) the oil will spoil rapidly and if fish is fried at too high a temperature, the batter will cook too quickly and too hard, while the fish at the centre may remain relatively uncooked. If the temperature is too low (because of the effect of the frozen fish), fat absorption will be greater and the food will be soft and greasy.

Frozen Food Generally - the points made in the section on frozen fish are true of frozen foods in general. As well as these, it must be remembered that free ice is often present in foodstuffs which have been frozen. This ice becomes water and produces steam during frying and there is therefore the danger of introducing excess moisture into the frying kettle with the food. Also, thick pieces of frozen food are difficult to cook right through, and they considerably reduce the temperature of the frying medium. As long as the food is small or in thin sections, this may not be a problem, but larger pieces benefit from thawing before frying. In this case, it is preferable to drain the defrosted food to remove excess moisture produced by the melting ice. Defrosted foods should be handled carefully, because they are often fragile.

Potatoes - potatoes should be stored in a cool, 7-10°C (45-50°F) dark, dry, airy place and not in close proximity to strong smelling produce or products.

Medium to large tubers tend to give a higher yield of long chips and many buyers therefore purchase supplies graded over a 45mm or 50mm square riddle. Potatoes with low dry matter content tend to produce soggy chips. Processors test samples with a potato hydrometer and will not usually use samples with dry matters below 19%. If the tubers have been stored at below 7-10°C (45-50°F) or are immature, the reducing sugar content may be too high (over 0.25%). Such samples produce dark brown chips. Samples can be test fried before purchase to eliminate those samples with excess sugar or which produce chips that turn black after cooking.

After peeling and chipping, the pieces should be kept soaking in water until required, to remove surface starch and to retard the development of discolouration or browning. Several proprietary potato 'whiteners' are available and these prevent discolouration; when used, the manufacturer's directions should be carefully followed. Too strong a solution, too long an immersion period or insufficient draining can result in a discolouration of the frying medium. In some cases, excess free starch on the potato is transferred to the frying medium where it will carbonise and cause the medium to deteriorate more rapidly.

Deep fried potatoes can be cooked by straight through methods or by blanching and browning in two stages. In the 'straight through' method, raw potato chips are deep fried at 188-191°C (370-375°F) until brown and cooked, (4-5 minutes). These can be stored for short periods in a warm dry place.

In the blanching and browning method, the potato chips are first blanched by frying at 168-177°C (330-350°F) until cooked but not brown (4-6 minutes). After draining, these can be stored, but should be refrigerated if kept for more than two hours. When required, blanched chips are browned by frying at 191°C (375°F) for 2-3 minutes. The advantage of this two-stage method is that much of the cooking process can be completed during slack periods.

Vegetables and Fruit - firm vegetables (cauliflower, carrot, onion) can be cut and separated into uniform pieces and fried at 177-191°C (350-375°F). Before frying the pieces are dusted with flour and dipped in batter, or soaked in milk or beaten egg and dipped in breadcrumbs or seasoned flour. Frying times will vary according to size but is generally between 2-4 minutes. Softer vegetables (corn etc.) can be mixed with a batter and spooned into the frying medium.

Fruit is generally dipped in fritter (that is, sweetened) batter and fried at 177-188°C (350-370°F) for 2-4 minutes depending on size and type. Pineapple, bananas, peach, apple slices etc. can be treated in this manner.

<u>Foods containing fat</u> - precautions should be taken against contaminating the frying medium with other fats. Sausages, chicken, beefburgers and other meat products all contain various amounts of fat which is still in its natural unrefined state. Obviously these will tend to melt during the frying process and their presence will lessen the life of the frying medium. Enclosing such food in batter before frying will tend to reduce this danger.

10. Recommended Frying Temperatures

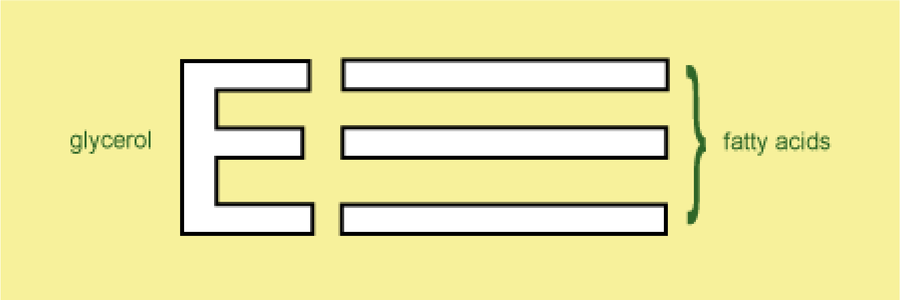
The actual temperatures and times used for frying will depend on the type of equipment used, the throughput and oil recovery rate, the size of the pieces being fried, the nature and condition of the frying fat or oil and upon local taste. However, the following temperatures and times are offered as a guide. Frozen foods may take up to a minute longer than the times indicated.

Items	Suggested Temperatures		Approximate Time (minutes)
	°C	°F	
Potato Chips, straight through	188	370	4-5
Potato Chips, blanching	166	330	4-6
Potato Chips, browning	191	375	2-3
Potato Chips, frozen, blanched	180	355	4-5
Fish (battered pieces)	188	370	3-5
Prawns and Scampi (battered)	177	350	3-5
Meat cutlets	177	350	3-6
Chicken Pieces	171	340	6-12
Sausages	177	350	1-2
Fruit Fritters	177	350	2-4
Vegetables	177	350	2-4
Onion Rings	177	350	2-4
Doughnuts	188	370	1-2
Choux paste	182	360	1-2

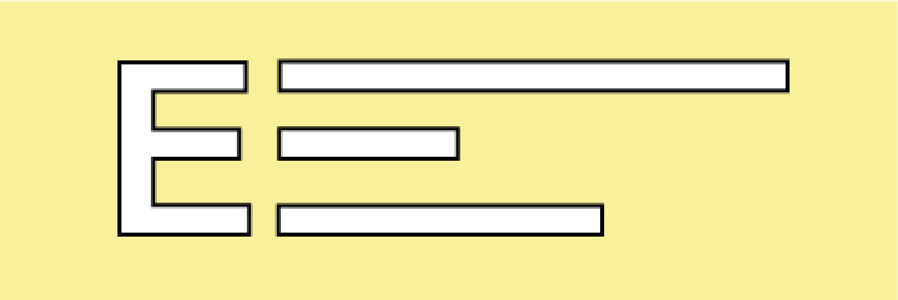
11. The Basic Chemistry of Fats and Oils

Fats and oils are obtained from a wide variety of sources and each one has its own individual properties. They are, however, all of the same chemical type. The basis of a fat is a substance called glycerol – the same material as the glycerine which can be obtained at a chemist's – which has a chemical formula which can be illustrated by the shape shown below left:

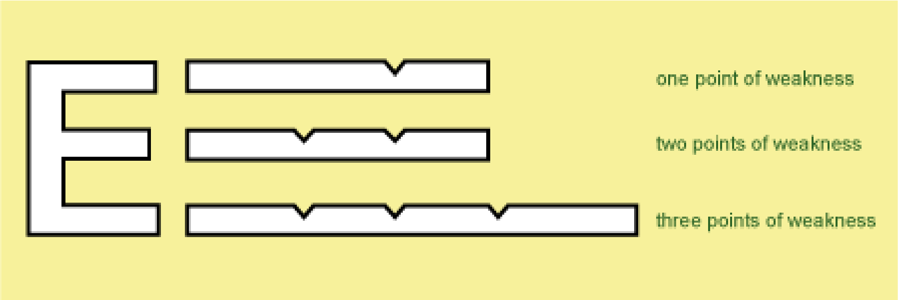
Each of the 'arms' of this shape can combine with another substance known as a fatty acid, to build up a molecule rather like the diagram below.



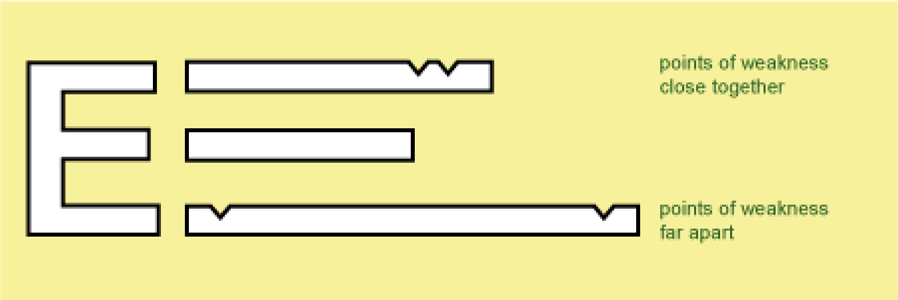
Because of the way in which its composition is built up, the chemical substance having this form is known as a triglyceride, and all fats and oils are made up of a mixture of these triglycerides. A number of different fatty acids exist and to a large extent the character of a particular oil or fat (and its frying properties) is dictated by the actual fatty acids which are present in the individual triglyceride molecules. Some of these component fatty acids are longer or shorter than others and they can all combine with a glycerol 'arm'.



There's another complication. Some of these fatty acids possess what could be called a point of weakness (a chemist would call it a double or triple bond) in the molecule. The reason for this is bound up with the chemistry of the molecule and its presence tends to make that particular material more sensitive and more unstable. To make matters worse, some fatty acids can have two of these points of weakness and some have three. The more there are, the more unstable the material is likely to be.



Finally, it is possible to have these points of weakness in different places. In the case of a fatty acid with two points of weakness, they can be sited to each other or far from each other. The closer they are together, the more unstable the resulting molecule will be.



From these descriptions, it can be seen that there can be hundreds of ways in which a triglyceride molecule may be built up. A particular fat is a mixture of many of these different triglycerides. The properties of lard are dictated to a large extent by the types of fatty acid which are present. Groundnut oil is also a mixture but the basic substances, though belonging to the same family, are slightly different and are present in different proportions.

12. <u>The Chemistry of Fat Spoilage</u>

Introduction

With a basic idea of the simple chemistry of fats and oils, it is possible to explain how they can spoil. Fats and oils are natural products obtained from plants and animals, and no matter how well they have been selected and refined, they will begin to spoil as time goes by. In frying, oil is forced to break down at a greater rate than normal because of the high temperatures which are involved.

Stages of spoilage

During frying, it is possible to define three different stages over which spoilage and breakdown can occur.

1 The storage period, which starts as soon as the fat is produced and ends when it is placed in the fryer. During this time, the fat is exposed to air at room temperature.

2 The standby period, when the fat is heated in the fryer, including the time taken to bring the fat up to frying temperature, and the time taken for it to cool when frying is finished. During this period, the fat is exposed to air at high temperature.

3 The frying period, when the fat is actually being used for frying. During this time, the fat is exposed to air, steam and the food being fried, at temperatures varying between 177-191C (350-375F).

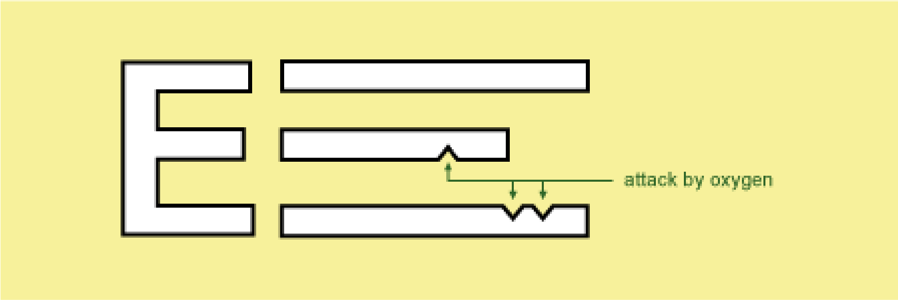
Reactions involved

There are a number of things which can break a fat down, and the type of reaction which takes place depends upon the particular period under consideration. The main reactions which can occur are summarised in the following table.

Period	Reaction	Speed of Reaction
Storage	Oxidation	Slow
Standby	Oxidation Isomerisation Polymerisation Pyrolysis	Fast Fast Slow Slow
Frying	Oxidation Isomerisation Polymerisation Pyrolysis Hydrolysis	Fast Fast Slow Slow Fast

Oxidation

During the storage period, the only chemical spoilage reaction which normally takes place is known as oxidation, attack by oxygen in the air, In fact, it is a special type of oxidation in which the products that are formed tend to promote the reaction, making it take place at an ever increasing rate. The oxygen in the air attacks the points of weakness in the fat that were mentioned in Section 11.



Obviously, the more points of weakness there are in a particular fat, the more the effect will be. In the storage period, it is some time before the effect becomes really noticeable.

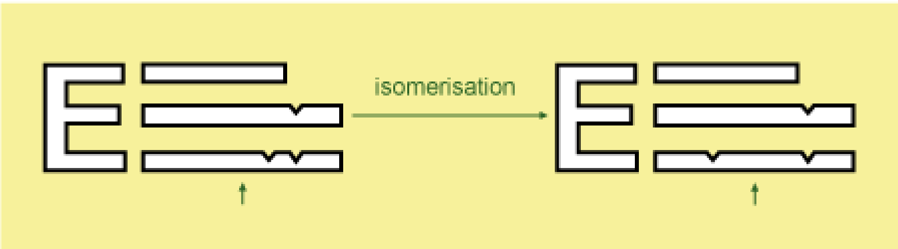
During the standby and frying periods, the fat is heated to about 191C (375F). Once a fat is heated, the process of oxidation, which was going on during storage, becomes much faster. As a result, the weak links in the fat are broken and new substances begin to be formed in the fryer. Unfortunately, most of these substances are evil smelling and are responsible in part, for the characteristic odour in a well-used fat and for off-tastes in the fried food.

Certain metals such as iron and copper accelerate oxidation of fats and should be avoided. For this reason it is also advisable not to add salt before frying, because the salt's sodium ions act as an oxidation catalyst. Salt also contains other impurities such as copper and iron ions. These impurities cause increased oxidation of the frying medium.

Isomerisation

This is another reaction which occurs rapidly in the standby and frying periods. In Section 11, when molecules with two points of weakness were discussed, it was mentioned that these points could be various distances apart; the closer together they are in the same molecule, the more unstable the molecule tends to be.

In the process of isomerisation, the molecule shuffles itself around and the points of weakness often end up closer together as a result. Isomerisation can therefore make the fat more unstable and more sensitive to oxidation.



Polymerisation

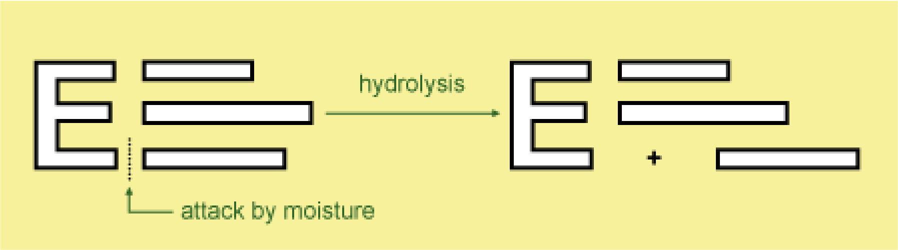
This means, simply, that two or more molecules of the same material have joined together to make a larger one. For example, polystyrene ceiling tiles and coving are made from a colourless liquid called styrene. The molecule of this liquid are made to join together – polymerise – to such an extent that they produce a solid. In frying, there is a tendency, more marked with some oils than others, for a yellowish-brown resin-like substance to be formed on the surfaces of the fryer and baskets. This substance is formed by the process of polymerisation.

Pyrolysis

This also occurs during the standby and frying period, although it proceeds at a slow rate. Pyrolysis is a sort of burning, where the fat simply breaks up into smaller compounds.

Hydrolysis

When food is fried in hot oil, this further reaction is introduced. The water which is present in the form of steam (from the chips for example) attacks the oil



This is the reverse reaction to the way in which the triglyceride molecule was built up at the beginning of Section 11, and the parts broken off are fatty acids. They are called 'free' fatty acids. The smoke point of oil is related to the amount of free fatty acids present and their breakdown products have objectionable smells. Eventually, they cause the oil and fried food to develop off-flavours.

Caustic Soda and other alkalis used for cleaning tend to promote hydrolysis and should be well rinsed away after they have been used.

13. <u>The Visible Effects of Chemical Spoilage</u>

It is interesting at this stage to study the frying process in the light of these reactions. When oil is heated and used for frying, a number of changes become apparent.

Distinctive odours and flavours develop

This is caused by the appearance of new compounds as the fat breaks down. Most of these new compounds have an objectionable smell and flavour but because they are relatively light I weight, they tend to be driven off by the steams as they are formed. They can be smelt in the atmosphere or tasted in the first pieces of food that are fried but eventually they can become more pronounced. They are mainly caused by the oxidation and hydrolysis of the fat (see Section 12).

The colour darkens

Most properly refined oils are pale in colour but as they are heated, they become darker until eventually they approach the colour of strong black coffee. This is mainly the result of the oxidation process which yields substances by mechanisms which are still not fully understood.

There are also colour changes taking place in the frying food, the surfaces taking on colour by caramelisation as it is cooked. These colours can dissolve in oil and will tend to darken the frying medium. Indeed, some of the dark colour is due to the presence of carbon in very fine form; so fine that filtration will not remove it.

The oil tends to smoke

The larger the quantity of fatty acids present in the heated oil, the more it tends to smoke. As the oil begins to deteriorate under the effect of heat, more of these breakdown products appear. Consequently smoke is formed at lower and lower temperatures as frying proceeds. As long as the frying areas is well ventilated, this may not be a serious performance fault in itself, but the smoke is acrid and objectionable and it serves as an indication of the condition of the oil.

Moreover; all the associated properties are affected, and the flash points and fire points are reduced, increasing the risk of fire. (See Section 16 about flash point and fire point).

The oil becomes thicker

As oil is heated, it becomes thicker and more viscous. This is mainly due to polymerisation, by which molecules join together to make larger ones. It is a serious performance fault as it causes a number of problems. As the oil becomes more viscous, fat absorption increases because the oil does not drain from the food so readily. Also, the bubbles which are formed at the surface are more stable, longer lasting. The amount of oil in contact with air at the surface is increased, and increased oxidation results.

The oil tends to foam

Some of the compounds which are formed when oil is heated are chemically related to those which are actually made commercially for their foaming properties. They are formed by oxidation and hydrolysis. At the same time, impurities can accelerate these reactions, particularly the presence of alkaline materials which might have been used to clean the kettles.

These reactions, as well as making the oil foam, also tend to increase the penetration of the oil into the fried food, which results in higher fat absorption.

Summary

There are five important effects of chemical spoilage which become visible in frying oil. They can be summarised in the next table:

Fault	Cause
Odours and Flavours Develop	Oxiidation, Hydrolysis
Smoke Forms	Oxiidation, Hydrolysis, Pyrolysis
Oil Foams	Oxiidation, Hydrolysis
Colour Darkens	Oxidation, Caramelisation
Oil Thickens Oil Forms Resins	Polymerisation, Oxidation Hydrolysis, Isomerisation

By presenting this information in another way, the following table shows the effects of ignoring some of the basic rules of frying:

Mistake	Main Reaction	Result				
		Odours Flavours	Smoke	Foaming	Colour Darkens	Oil Thickens
Frying too hot	Oxidation	●	●	●	●	●
	Isomerisation					●
	Polymerisation					●
	Pyrolysis		●			
	Hydrolysis	●	●	●		●
Melting out carelessly	Pyrolysis		●			
Wet food	Hydrolysis	●	●	●		●
Fragile food	Caramelisation				●	
Frying fatty foods	Oxidation	●	●	●	●	●
Not cleaning	Caramelisation				●	
Not rinsing	Hydrolysis	●	●	●		●
Iron or copper present	Oxidation	●	●	●	●	●

14. <u>The Role of the Oil Refiner</u>

The oil refiner can do a number of things to help damp down the chemical spoilage of a frying oil or fat.

Oils have different stabilities towards heat and frying, and these differences are due to their basic chemistry. In particular these differences are related to the number of points of weakness in the molecule. Some oils and fats are stable enough for many food applications, but are too sensitive to heat to merit consideration for use as a frying medium. The refiner will know from experience which oils, and which blend of oils are likely to give better performance than others. Those which find commonest use include palm, soyabean and rapeseed oils, lard and tallow or dripping; also available are corn, groundnut and cottonseed oils, but these are generally more expensive.

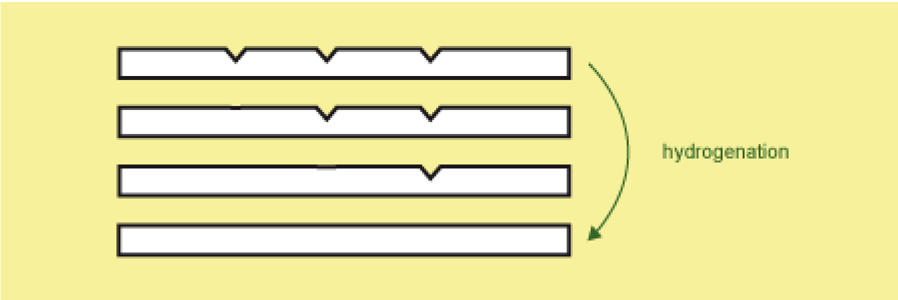
It is more important to properly refine a frying fat or oil than any other. If all the impurities naturally present in the crude oil are not removed in the refining process, they can cause all these spoilage reactions to go on at a faster rate. Naturally occurring emulsifiers such as lecithin, which is found in most crude oils, will cause a frying medium to smoke or discolour sooner. Small quantities of metal elements such as copper and iron are fatal because they will provoke the reaction known as oxidation. Special efforts are made by the refiner to remove these metals and in normal circumstances; one would expect to find less than one part of them in about one million parts of refined oil. This care can be completely cancelled out by the fryer by using equipment containing, say copper or brass.

The refiner can use additives to improve the stability of his oil. Antioxidants, for example are permitted additives which slow down the rate of oxidation. This effect is most marked in the storage period, when it delays the onset of spoilage by oxidation. Once the oil is heated to frying temperature, this effect tends to be lost because the antioxidant is eventually boiled off.

The refiner can also add substances known as antifoaming agents. These tend to reduce the amount of frothing or foaming which takes place at the surface of the fat and by doing this, they cut down the rate of deterioration, particularly that caused by oxidation. Because antifoaming agents are extremely effective, the average rate of addition is as low as two parts per million.

It is also possible to improve the stability of an oil or fat by chemical modification. In section 11, there appeared a number of diagrams which illustrated the shape of fat molecules. Most of them had 'points of weakness' in them to greater or lesser extents. In general, the more points of weakness there are, particularly if they are close together, the less stable the oil will be towards heating and the less stable it will be towards frying. That is because (see Section 12), the spoilage reaction known as oxidation can occur at these points of weakness.

It is possible to use a chemical process to reduce the number of points of weakness in a fat or oil



This process is called hydrogenation and it is achieved by bubbling gas called hydrogen through the heated oil under very carefully controlled conditions. It results in the gradual disappearance of these points of weakness and because of this, the oil becomes more stable. The melting point of the oil is increase at the same time, and because of this, the process is often called 'hardening'.

Physical modification of oils is also possible, and it can take several forms. For example, it is possible to take fat which is normally solid at room temperature, melt it and allow it to cool slowly in a tank so that it begins to crystalise. After allowing this to occur, it can be filtered to give a liquid portion and solid portion. Palm Oil can be subjected to this process and the liquid part which is obtained can be used as frying oil.

To summarise, an oil refiner can use a number of techniques in order to produce a frying medium, of good performance:

Choice of oil – Proper refining – Use of additives - Chemical modification – Physical modification.

15. The Role of the Fryer

A number of spoilage reactions were described in section 12, and their effects were discussed in section 13. It doesn't matter how carefully the frying process is conducted, all these spoilage reactions will be going on in the fryer to some extent.

However, if good fats and good frying practices are used, some of the effects can be minimised. This is why the food should be as dry as possible, why cleaning both the oil and the equipment should be carried our regularly, and why the oil should not be overheated. The hotter the oil, the faster will be the rate of all these reactions. However, frying must be carried out at a certain minimum temperature, or the fried food will be greasy and the fat usage (by absorption) will go up. Therefore, a watchful eye should be kept on the temperature, and thermostats should be checked regularly to make sure they are working correctly.

In a more optimistic vein, there is a tendency for the heat and steam generated during frying to drive off some of the breakdown products that are formed. Also, if the fryer is regularly topped up with fresh fat, the effect of these spoilage reactions may be damped down so that they might not get out of hand. Because of this last point, it is advisable to fry the correct proportion of food to fat. In general, the best ration appears to be to fry one part of food in six parts of fat.

It is not necessarily wise to economise by only filling the fryer, say, and half full of oil or fat. The specific surface area of the frying medium is the surface area of the medium divided by its volume. The specific surface area of a half full fryer is twice that of a full fryer. That is to say, twice the proportion of frying medium is on the surface if the fryer is half full. Reference to the first table in section 13 will show that oxidation is one of the most common breakdown reactions in frying. Oxidation is a result of the oxygen of the air attacking the frying medium, and common sense will indicate that oxidation occurs at the surface of the fat or oil. It can therefore be argued that, the shallower the oil in the fryer, the bigger proportion of it will be at the surface, and the more important oxidation becomes.

Remember, that as soon as oil is heated, it will begin to break down, however good it is. It is best to keep the oil as busy as possible. Never heat three fryers when two will do.

16. <u>Fire Hazards</u>

Fire Properties of oils and fats

Oil is a fire hazard. In general, there is little difference in the fire properties of refined oils and fats of various types. Most refined oils have flash points of between 310-330C (590-625F), the flash point being the temperature at which the oil is capable of being ignited but not of supporting combustion. Most refined oils have fire points in the range of 365-375C (690-710F), the fire point being the temperature at which the oil will support continued combustion. In the case of unrefined oils and fats (some drippings, for example), or fats which have already deteriorated by heating, these figures are correspondingly lower.

Preventing Fires

In commercial frying processes, it appears that most fires occur because a thermostat has failed after a kettle has been left unattended. They can also be caused by the frying medium frothing over (because of the continued frying of wet food for example), particularly when a naked flame is nearby or is used as the source of heat. Once started, a fire can quickly spread to the ducting of an exhaust system, particularly if this is not regularly cleaned or fitted with a fat filter.

Putting out a fire

If noticed early, many fires can be extinguished by cutting of the source of heat and closing the lid of the equipment (if there is one), and /or covering the burning oil with a fire blanket. The blanket should be left in position for at least 20 minutes to ensure that the temperature has dropped below the fire point. Foam can be used, but this should be allowed to fall gently onto the burning oil, otherwise the fire may spread.

Warn the occupants of the building and alert the Fire Brigade.

Summary

Never overheat oil. Always dry the food as much as possible before frying to minimise frothing. Never leave the kettle unattended while the oil is heating.

Fit a thermostat. An overriding thermal cut out is also useful. Regularly clean ducting and exhaust system. Keep fire-fighting equipment handy. Have a word with the local Fire Officer. If a fire starts, switch of the heat and close the lid of the kettle. Cover the fire with a fire blanket and leave in position for at least 20 minutes. Warn the occupants of the building and alert the local Fire Brigade.

Footnote - Do not put hot oil into plastic containers.

Reproduced with the kind permission of ADM Pura.