Ensuring quality and shelf life

When it comes to oils and fats, good things can come in many packages, with metal, glass and plastic all utilised today. Each material offers advantages and drawbacks. Other factors – such as oil-package interactions, packaging geometry and filling and capping systems – must also be taken into account to ensure product quality

PHOTO: ADOBE STOCK

PLASTIC BOTTLES HAVE BEEN INCREASINGLY USED TO PACKAGE EDIBLE OILS IN RECENT YEARS DUE TO THEIR RELATIVELY LOW PRICE AND WEIGHT AND EASE OF HANDLING.

Packaging is a very important factor for any food product and, when it comes to edible oils, incorrect storage practices can influence the sensory quality of an oil, leading to rancidity and off-flavours.

Oils and fats spoil due to environmental factors that affect their stability, namely oxygen, moisture, heat and light, according an Indian Centre for Plastic in the Environment (ICPE) publication.

Oxygen is the most critical factor affecting stability. The presence of oxygen leads to oxidation and formation of hydroperoxides and peroxides and then aldehydes and ketones, resulting in off-odours.

These reactions increase in rate and intensity in the presence of light and heat.

Each oil or fat has a different degree of susceptibility to oxidation, depending on their fatty acid composition. Oils containing a high degree of unsaturated fatty acids – such as safflower, soya and sunflower – are highly prone to oxidative rancidity, whereas oils with a high degree of saturated fatty acids are less susceptible, the ICPE says.

In unrefined oil, natural antioxidants are present and the oil is therefore less prone to rancidity compared with refined oil, when antioxidants are removed during the refining process. Often, oil manufacturers will then add antioxidants to refined oil in order to extend the shelf-life of the product.

Oxygen may gain access to oils or fats in several ways. Atmospheric oxygen may be present in the oil. It may also be present in the headspace of the package, or may enter the package through the body or the seals.

Another important factor that contributes to the deterioration of oil is moisture, with even very small amounts of moisture being detrimental.

Hydrolysis of triglycerides results in the formation of glycerol and free fatty acids, and off-flavours may occur due to hydrolytic rancidity.

This is more common in oil and fats with high levels of saturated fatty acids. Moisture may also gain entry through the body or seams of packaging by permeation.

Light and heat act as initiators of oxidation reactions, which ultimately lead to degradation. Therefore, control of these factors is also important.

Traditionally, oil and fats were packed in tinplate containers but other types of packaging, such as plastic containers, lined cartons and flexible pouches are now used, says the ICPE.

Today, the array and availability of packaging materials, sizes and shapes of package construction are unlimited. Modern packaging technology provides many opportunities to maintain product protection while reducing the cost. Any packaging system for edible oils and fats should be:

- Non-toxic and compatible
- Protect against environmental factors
- Machineable
- Leak-proof and transport-worthy
- Easy to store, use and handle

Packaging selection

Marketing and economics are usually the factors driving the selection of packaging. However, proper packaging will provide the conditions to ensure adequate shelf life for distribution and sale, according to the Luciano Piergiovanni and Sara Limbo of the Department of Food Science and Microbiology, University of Milan, Italy.

Even though oils are quite stable products, physicochemical characteristics of packaging materials may significantly affect oil quality during their shelf life, they write in the book, *'Food Packaging and Shelf Life – a Practical Guide'*.

In addition, packaging geometry, and filling and closing techniques may also be very important.

Physicochemical characteristics: Oxygen permeability and ultraviolet (UV)/visible light transmission are the major physicochemical factors, due to the oxidative sensitivity of vegetable oils. Oxygen permeability applies to plastic materials only, whereas light transmission is important for glass and plastic. Many additives are available to reduce UV transmission in both plastics and glass.

Packaging geometry: The geometry of packaging can act in different ways to protect the product. The size and shape of plastic packages can affect the ratio between permeable surface area and product volume. For plastic, glass or metal packages, shape and size can influence the headspace and, therefore, the amount of oxygen available.

Filling and capping: The filling and capping steps are relevant in the process of oil packaging. In order to reduce the residual oxygen inside bottles, the oil is generally stripped with gaseous nitrogen to lower the initial level to below 0.5ppm. Gaseous nitrogen can be pressurised by injecting liquid nitrogen into the headspace prior to closing.

The effectiveness of closures is also important in order to reduce oxygen ingress during shelf life. Closure efficiency is related to several factors including material used, design and liner adopted.

These factors must guarantee hermeticity, easy opening and the possibility of reclosing. As these goals are sometimes contradictory, efforts to develop new devices is ongoing, including the use of active and intelligent packaging.

Oil-package interactions: Selection of packaging materials may also be made based on their interaction with oils. Oil-package interactions can affect product shelf life, reducing nutritional value and stability – by scalping – or increasing the level of chemical contamination by migration.

Generally speaking, glass is the most inert material, followed by metals and plastics. Plastic packaging can absorb different compounds from food in a phenomenon called scalping (sorption).

In particular, flavour scalping is a term used to describe the loss of quality of a packaged food due to either its volatile flavors being absorbed by the package or the food absorbing undesirable flavours from the packaging material. Several investigations have shown that considerable amounts of aroma compounds can be absorbed by plastic packaging materials, resulting in loss of aroma intensity or unbalanced flavour profiles.

In addition, non-volatile compounds may be absorbed by packaging materials, affecting the packaging itself, such as its permeability, barrier and mechanical properties, or causing delamination of multi-layer package.

Migration is an important safety aspect to be considered when selecting food packaging materials.

Plastic additives and residual monomers or oligomers are not chemically bound to the polymermolecules and can, therefore, move freely within the polymer matrix. Consequently, at the interface between the packaging material and food, they can dissolve in the food product and adversely affect the flavour and acceptability of the food.

The chemical nature of the packaging material has a notable influence on oil quality.

A review by Kanavouras et al (2006) suggested that edible oils should not be stored in polyvinyl chloride (PVC) plastic materials as vinyl chloride monomer (VCM) and plasticisers can migrate into fatty foods, leading to the contamination of the oils.

Polyethylene terephthalate (PET) is one of the most inert plastics and, in recent years, packing of oil into PET bottles has increased. Nevertheless, PET monomers, oligomers (cyclic trimers, pentamers, heptamers), plasticisers, colourants, stabilisers and different additives used for flexibility purposes are all prone to migration.The migration of acetaldehyde from PET bottles is a major problem, as its presence may affect the organoleptic properties of oil.

In general, PET bottles are usually considered suitable to contain not only seed oil but also olive oil.

Packaging materials

Metal: Tinplate containers have been used for a long time for oil packaging and are still appreciated because of their many advantages. They provide total protection against light, oxygen, water vapour and micro-organisms.

In addition, the inside of the container is protected with food-approved special enamels (lacquers) that protect the metal from the corrosiveness of the product.

Edible oils are generally packed in tinplate containers of different capacities, typically from 500g to 15kg.

The quality of oil packed in new containers can remain unchanged for a year. However, reuse of containers increases corrosion of the tin coating and the exposed steel base readily reacts with the free fatty acids in oil, leading to oxidative rancidity and organic tin salts with high toxicity.

Aluminium is also employed as a packaging material for edible oils as it is light and highly resistant to corrosion. In order to increase its mechanical resistance, aluminium alloys with small amounts of magnesium, manganese, and magnesium silicide are recommended.

PHOTO: ADOBE STOCK

COLOURED GLASS BOTTLES ARE WIDELY USED TO PACKAGE OLIVE OILS TO PREVENT OR SLOW THE OXIDATION PROCESS

All these metallic containers are considered inert against oils, even though trace levels of metal ions – such as iron and copper – are known to have adverse effects on the oxidative stability of olive oil.

Glass: Glass bottles are heavy and fragile but are widely used for bottling olive oils and virgin olive oils in particular. This is not only due to marketing factors but also because glass containers prevent the permeation of oxygen molecules into the bottle, slowing down the autoxidation rate.

Transparent glass, however, leads to photo-oxidation of olive oil and reduction of its shelf life. The use of coloured glass bottles prevents or slows down the oxidation process.

Metal and glass are the only packaging materials that provide a virtually total barrier to moisture and gases. The word 'virtually' is used because such containers require a closure that incorporates other materials, such as polymeric sealing compounds in cans and in closures, through which oxygen can easily permeate and promote oxidation.

The shelf life of edible oils packaged in metal containers or non-transparent glass bottles is dictated by the initial quality of the oil, processing conditions and filling operations.

Plastic: Plastic containers are a relatively new means of packaging edible oil and have been increasingly used in recent years due to their relatively low price and weight and ease of handling.

The polymers most frequently used are PET, high density polyethylene (HDPE) and PVC. Although they do not provide as long a shelf life as metal containers, they are economical and suitable for use where a very long shelf life is not required.

PET is one of the most commonly used plastics in food packaging covering a wide range of packaging structures. It satisfies many important requirements including good aesthetic aspect with brilliance and transparency; suitability for colouring; good mechanical, thermal, and chemical resistance; low production cost; good barrier properties against CO_2; suitability for prolonged storage, easy recyclability and low weight.

The trend toward incorporating modifier compounds into PET packaging resins has grown in order to produce containers with a high degree of clarity, in a wide variety of custom shapes, and free from residual acetaldehyde.

In addition, the incorporation of antioxidant stabilisers in PET increases its application in the food area, particularly for vegetable oil storage.

HDPE is largely used as a packaging material because of its tensile strength and hardness and good chemical resistance. Blow-moulded HDPE containers in the form of bottles, jars, and jerry cans are used for packaging edible oils.

PVC is a popular packaging material for edible oils in many countries, mainly due to its transparency, adaptability to all types of closures, total compatibility with existing packaging lines, and potential for personalised design features.

Mainly driven by issues such as the protection of the environment, PET has been supplanting PVC in the edible oil market.

As with other transparent plastic materials, PVC increases light exposure of the oil, enhancing oxidation. UV absorbers can be added to plastic materials in order to reduce their light transmission.

Multi-layer pouches and paper-based cartons: In recent years, the adoption of multi-layer pouches for oil storage has increased due to consumer preference for unit packages. Generally, limited quantities of edible oil are packed in flexible pouches (up to 500g). Flexible pouches may be manufactured from laminates or multi-layered films of different compositions and the pouches may be in the form of a pillow or stand-up pouch.

The selection of a laminate or multi-layer film is governed primarily by the compatibility of the contact layer, heat sealability, heat seal strength, and shelf life required, together with machinability and physical strength parameters.

Active packaging: In order to reduce the diffusion of oxygen into bottled oil, various solutions have been used. The most popular involves the use of 'oxygen scavengers' (OS), which remove oxygen dissolved in the oil and provide a barrier to oxygen diffusion from the atmosphere. These scavengers can be easily incorporated into the packing material without altering its other properties.

Conclusion

With such a wide array of packaging materials available to oils and fats manufacturers, the selection of packaging combines both marketing, product quality and economic factors.

Good packaging will ensure product safety and quality, as well as contributing to low wastage and better logistics. It will also ensure good shelf appeal, branding and visibility. ●

This article is based on information from Chapter 17 of the book, 'Food Packaging and Shelf Life – a Practical Guide', written by Luciano Piergiovanni and Sara Limbo of the Department of Food Science and Microbiology, University of Milan, Italy