PET PACKAGES, WITH UV BARRIER PROTECTION, FOR PACKAGED OLIVE OIL STORAGE

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ABSTRACT

The incorporation of colorants and UV absorbers in PET (Polyethylene terephthalate) material forms the basis of several studies in the food packaging sector. The main objective of this kind of additives incorporation is to increase the light transmission barrier of the material, maintaining the food quality properties (commercial, nutritional and sensory properties) and increasing the food shelf-life. A great amount of olive oil is currently offered in clear PET packaging. Practically all vegetable or seed-based oils contain varying levels of unsaturated olefinic acids or esters (e.g. linoleates) which are susceptible to light-induced degradation. The incorporation of a low percentage of UV absorber can significantly reduce the UV light transmission. The UV absorbers and colorants incorporation addition rates into the PET material, during transformation process (injection and blow molding), is quite important to know which the most effective is. Collaboration between UV Absorber/Colorant additive suppliers and PET converters is significant for achieving the goal.

1. Introduction

Three countries are the major olive oil producers in the world. First is Spain, second is Italy and third is Greece. Together, they produce more than 75% of the world’s product. Greece has by far the largest per capita consumption of olive oil worldwide, over 26 liters (l) per person per year; Spain and Italy, around 14l; Tunisia, Portugal, Syria, Jordan and Lebanon, around 8l. Northern Europe and North America consume far less, around 0.7l, but the consumption of olive oil outside its home territory has been rising steadily [1].

Oxidation constitutes a major factor in the deterioration of olive oil quality. The rate of oxidation depends on a number of factors, including the availability of oxygen, presence of light and temperature. When vegetable oils are exposed to light, photo-oxidation occurs through the action of natural photosensitizers (i.e. chlorophyll), which react with triplet oxygen to form the excited state singlet oxygen. Singlet oxygen then forms a free radical from unsaturated fatty acids leading to the production of hydroperoxides and eventually to carbonyl compounds resulting in the development of undesirable off flavours in edible oils [2]. Protection from direct light is required for commercial olive oil.

Various types of materials can be used for olive oil packaging and the degree to which each provides protection from oxygen and light can have a significant influence on the product quality. Among the packaging materials used for olive oil packaging, there
are: glass, metals, plastics and plastic coated paperboard. PET (polyethylene terephthalate) is the most important plastic used for olive oil packaging, due to its clarity, chemical inertness, low oxygen permeability and excellent mechanical properties. The incorporation of UV absorbers or colorants has the ability to improve the effectiveness of PET for packaging olive oil, maintaining its quality properties and increasing shelf-life during storage.

2. Experimental and results

2.1 UV Light barrier additives in PET

Many food and beverage products are sensitive to UV light and exposure can result in changes in taste, odour and texture. UV light can also degrade colored dyes in plastics. Protecting UV sensitive products, extending shelf life and maintaining the container aesthetic, while maintaining cost-effective production processes, can pose a challenge for manufacturers.

Ultimate UV Light Barrier technologies from ColorMatrix can be used for a wide range of container thicknesses and offer a cost-effective light barrier solution for protecting UV sensitive products packaged in PET. ColorMatrix works closely with customers to model usage rates and to ensure that dosing of Ultimate UV products is optimized and product protection is assured for the required life of the product.

There are two grades of Ultimate UV Light Barrier protection available:

- Ultimate UV370 - light blocking at 370nm<10% transmission
- Ultimate UV390 – light blocking at 395nm<10% transmission

Ultimate UV390 provides full broadband UV protection against light degradation, allowing less than 10% UV light transmission up to 395nm - the edge of the visible spectrum.
Ultimate UV products are formulated for global use and can be used in combination with other ColorMatrix colorant and additive formulations. Ultimate UV light barrier technology, used in combination with ColorMatrix colorants, can offer enhanced light protection into the visible range, particularly relevant to vitamin enhanced products. Protection up to 575 nm is possible, whilst also maintaining container transparency.

Ultimate UV technology can be particularly effective in maintaining product protection where light weighting is required, which generally means the container wall thickness is reduced. The reduced wall thickness makes the product more susceptible to UV light. As a result, the level of UV blocker usually has to be increased to compensate for the reduced protection provided by the packaging wall and this can also increase cost.

As a liquid dispersion, Ultimate UV delivers high-level dosing accuracy, making it a highly cost effective solution. It is also dosed directly into the machine, making it easy to process and control with excellent consistency and helps to eliminate mold plate-out, which can lead to downtime issues.

Container aesthetics is paramount for brand image, consistency and shelf impact. Highly consistent dosing offers excellent part clarity with a superior aesthetic. The addition of Ultimate UV products has no negative impact on recyclability, physical performance characteristics or color of the recycled material. Ultimate UV is the only UV barrier additive for PET that is currently recognised by the Association of Plastics Recyclers (US) and the European PET Bottle Platform for having no negative impact on the recycling stream.

Ultimate UV products are suitable for use under EU and FDA food contact legislation.

2.2 Incorporation of colorants and additives in PET material in the preform injection and blow molding process

As mentioned before, PET material is highly suitable for the manufacture of containers or packages for comestibles such as beverages and food. Caiba, S.A. is a PET package manufacturer that incorporates UV absorber barrier and colorants into its preforms. Rigid containers may be manufactured by known mechanical processes [3]:

a) Single-stage blow molding, such as performed on Nissei, Aoki, or Uniloy machines,
b) Two-stage, injection molding of preforms such as on Netstal or Husky machines, and preforms converted to bottles by blow molding (e.g. on Sidel, Corpoplast and Krones machines),
c) Integrated blow molding of preforms to bottles, such as processes conducted on Sipa,
d) Krupp Kautex, or Husky ISB machines, and
e) Stretch blow molding (SBM) of preforms to bottles.

The preforms may be monolayer or multilayer. The bottles may be post-treated to alter the inner wall properties or surface treated on the exterior e.g. applying a surface coating. UV absorbers and other known stabilizers may be present in such added surface coatings.

US 5,948,458 teaches the protection of foods containing unsaturated lipids and fats (i.e. olive oil) due to exposure to UV radiation by incorporation of calcium phosphate compounds either directly into the food product itself or in the food coatings and package wrap.

It has been found that certain UV absorbers of the class of durable benzotriazoles and triaryl-striazines are especially effective in protecting the contents of clear, lightly colored and thin-walled containers and films.
The description, preparation and uses of the 2H-benzotriazole UV absorbers are described in US 3,004,896; 3,055,896; 3,072,585, among others: injection process (colorants/additives incorporation, liquid or masterbatch).

ColorMatrix liquid color and additive dispersions, used individually or as combination products, incorporate more effectively into the polymer achieving higher quality, more consistent distribution and superior aesthetic characteristics.

ColorMatrix has a detailed understanding of the dispersion of its products for use in a wide range of polymers and offers advanced liquid carrier systems specially formulated for PET and PET preform injection molded process.

ColorMatrix carriers largely comprise natural oil based materials from renewable sources helping with sustainability, while the processing of liquid colorant and additives in preform moulding frequently requires lower energy than alternative systems.

Caiba S.A. incorporates UV absorbers or colorants into PET resin through the following process: the UV absorbers/additives are prepared using a twin screw extruder at an operating temperature at die of approximately 275°C. The concentrates are letdown with base resin to the final additive loading, indicated by the additive supplier. PET is dried in vacuum for at least 4 hours at 180°C prior to preform molding. Preforms are molded on a unit cavity using the minimum injection temperature and back pressure necessary to obtain parts free of haze and crystallinity.

Dosing accuracy, low inventory and fast colour change times minimize waste and reduce environmental impact. The best of the
gravimetric solid systems claim to dispense colorants with a high degree of accuracy. ColorMatrix liquid colorant and additives, in conjunction with the Company’s volumetric liquid dosing systems, offer even greater dosing accuracy, down to addition rates as low as 0.001%. The inherent accuracy of a volumetric liquid system gives greater control over shot-weight fluctuation.

ColorMatrix liquid colorants can enable smooth, efficient processing, eliminating processing issues such as screw slip, even on the very latest processing equipment.

- Blow molding process

Bottle blow molding is conducted using a Sidel SBO2, SBO4, among others, blow molding machine, using PET preforms which incorporate this type of additive.

Colorants and UV absorbers use extremely small particles of titanium dioxide (TiO₂) to efficiently absorb ultraviolet light. Depending on additive dosing of TiO₂ into the preform, processing parameters of the blowing machines have to be changed to achieve a suitable bottle.

For blow-molded bottle manufacturing, the preferred polyesters have a I.V. around 0.8, and Tg>70ºC, and film sections cut from the bottle have a Water Vapour Transmission Rate of 1.5 to 2.5cc/m2·day, a Carbon Dioxide Rate of 20 to 30 cc/m2·day, and an Oxygen Permeability of 4 to 8cc/m2·day.

2.3 Improvement of the packaged olive oil in PET bottles incorporating UV barrier protection and colorants

Olive oil quality is defined from commercial, nutritional and sensory perspectives. The nutritional value of olive oil is due to its high content of monounsaturated oleic acid and minor constituents such as phenolic compounds, tocopherols and carotenoids, while its sensory properties (mainly aroma) is the result of a complex mixture of volatile compounds [2].

Quality parameters monitored throughout the olive oil storage period are: acidity, peroxide value (PV), spectrophotometric indices (K232, K270) and color. Temperature, light and headspace volume influence these parameters during olive oil storage.

Olive oil deterioration in the presence of light is enhanced by trace constituents such as chlorophyll, which are excited through the absorption of light. Subsequently they transfer this excess energy to ground state triplet oxygen to form the excited state singlet oxygen which readily reacts with free fatty acids [2].
Reactions contributing to an increase in peroxide value (PV) are auto-oxidation and photo-oxidation. The former occurring in the absence of light while the latter occurs in the presence of light.

Changes in olive oil colour are related to the decomposition of chlorophylls during photo-oxidation. The color of commercial olive oils appearing on the market varies from yellow through to greenish yellow to green and is sometimes almost colorless. As is well known, the natural or original color of the oil at the time of production depends on a number of factors, such as the variety of olive, climatic and soil conditions under which it is grown, ripeness of the fruit and the method of pressing and refining. Generally, the fruit is gathered just before the period of maturity which produces an oil of superior quality to that expressed from the ripe or over-ripe fruit [4].

Pristouri (2010) mentions that dark colored PET container is more appropriate material than PET and PET UV-absorber.

Caiba, S.A. introduces between 0.02% and 0.06% of green colorant in the PET preforms during the injection molding process, to give
light barrier in the blow molding bottles, and for olive oil packaging.

Image 9: Caiba olive oil bottles.

REFERENCES


