

Report

Packaging influences on olive oil quality: A review of the literature

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August 2014

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Packaging Influences on Olive Oil Quality: A Review of the Literature

Extra virgin olive oil is a fresh juice extracted from olive fruits. As with other fruit juices, the freshness and flavor quality of olive oil diminish with time, and the rate of deterioration is influenced by packaging type. To maximize shelf stability, the ideal packaging material would prevent light and air penetration, and the oils would be stored in the dark at 16 – 18 °C (61 – 64 °F). Table 1 indicates how chemical components in olive oil influence the shelf life of the oil.

Table 1. How chemical components in the oil can influence shelf life

Chemical component	Effect on the shelf life
Fatty acid profile	High level of polyunsaturated fats such as linoleic acid and linolenic acid shortens shelf life; high level of saturated fats such as stearic acid and palmitic acid helps to prolong shelf life.
Free fatty acidity	Free fatty acids promote oxidation and shorten shelf life.
Peroxide value	High level of peroxide value shortens shelf life.
Trace metals	Trace metals promote oxidation and shorten shelf life.
Oxygen	Oxygen promotes oxidation and shortens shelf life.
Moisture	Moisture promotes oxidation and shortens shelf life.
Phenolic content	Phenolics are antioxidants and help to prolong shelf life.

While a high quality olive oil under ideal storage conditions can be stored for months, even years, without becoming rancid, oxidation ultimately will lead to rancid flavors and aromas. There has been extensive research interest in commercial olive oil packaging that assesses impact on shelf life, especially in the past ten years. In this review, we summarize the current literature on commercial packaging for olive oil, highlighting the advantages and disadvantages of various types for oil stability, price, weight, durability, consumer acceptance and sustainability.

Glass is a well-researched packaging material for olive oil. Dark glass provides better protection from light than clear glass, but both offer better protection for the oil than plastic materials. Clear glass has higher consumer acceptance than colored glass, but photo-oxidation takes place more easily in clear glass, so it would be advisable to either almost completely cover clear glass packages with a label or UV blocker, or to also include a cardboard case for the bottle. Disadvantages of glass include its fragility and heavy weight. Parallel comparison between different colored glass containers (i.e., amber and green) is lacking in published olive oil research.

Aluminum packaging for olive oil has not been studied extensively. Aluminum provides protection from light and oxygen, but high cost can be a disadvantage. It is best to coat the interior of aluminum packages with a food-grade enamel coating to prevent toxic aluminum ions from migrating into the oil and diminishing oil quality.

Tinplate cans have been recommended by some researchers because tinplate blocks light and oxygen while also offering the advantage of being lightweight. Other researchers have found tinplate to be inadequate, which may be due to some of the studies using oils that had degraded in quality while sitting on

sediment. It is not advisable to refill tinfoil cans because these containers corrode and release compounds over time that accelerate oxidative reactions, thus leading to a much lower shelf life for the oil.

Stainless steel provides excellent protection from oxygen, light, humidity and microorganisms and is the best bulk storage option for olive oil producers. However, its high cost and heavy weight may make it less suitable for commercial packaging.

Plastic materials have the advantages of being lightweight and durable. A major disadvantage of plastic materials is their porosity, which permits the penetration of air and humidity. Light penetration is an additional disadvantage of clear plastics. Migration of small molecules from plastic can diminish oil quality and food safety. At one time, polyvinyl chloride (PVC) was a popular packaging material for edible oils, but these containers were supplanted by polyethylene terephthalate (PET) because harmful vinyl chloride monomers (VCM) in PVC would dissolve during storage. PET is more resistant to oxygen and fat permeability than other plastic materials. Adding radical scavengers and/or oxygen barriers to PET will enhance protection of the oil, although these improvements would increase costs (by about 17 percent just for the oxygen barriers).

Coated paperboard is highly effective in protecting olive oil quality by blocking oxygen and light. Consumer acceptance for the packaging is mixed, although the packaging is used by some high-volume brands.

Bag-in-box packaging consists of a strong plastic bag (with layers of metalized film or other liners) inside of a corrugated-fiber box. The type of plastics used for the bag can influence the shelf life of the oil. Bag-in-box packaging shares similar advantages and disadvantages with coated paperboard, providing excellent protection from light and oxygen, inexpensive, lightweight, but not reusable. This packaging has been used for decades in the wine industry, though it's becoming more common in commercial packaging for olive oil in the food service sector. It has the potential to be one of the best commercial packaging options, but has not been the topic of published research.

Table 2. Advantages and disadvantages of olive oil packaging materials

Material	Advantages	Disadvantages
Colored glass (amber/green)	<ul style="list-style-type: none"> Widely used in beverage and food containers and better than plastic and clear containers¹ Protection from both oxygen and light Easy to sterilize, reused glass bottles provide cost benefits with an effective recycling system,² eco-friendly 	<ul style="list-style-type: none"> Breakable and heavy: low resistance to mechanical damage, difficult in transportation and storage³ Plastic closure may be a weak point of the package⁴ Expensive
Clear glass	<ul style="list-style-type: none"> Widely used in beverage and food containers Protection from oxygen, good option for dark storage Consumers appreciate transparent glass because they can see the oil color, some industry evidence that clear glass sells better than colored glass Easy to sterilize, reused glass bottles provide cost benefits with an effective recycling system², eco-friendly 	<ul style="list-style-type: none"> Light can penetrate thus accelerating oil oxidation – can be improved by supplying the clear glass with a cardboard case or by covering the glass with label Breakable and heavy: low resistance to mechanical damage, difficult in transportation and storage³ Plastic closure may be a weak point of the package⁴ Expensive
Aluminum	<ul style="list-style-type: none"> Can indicate a premium product Used as aluminum alloys with Mg, Mn and Si/Mg to increase the resistance to mechanical damage⁵ Protection from both oxygen and light Best with food-grade enamel coating (usually polymeric materials)⁴ Lightweight Recyclable and eco-friendly 	<ul style="list-style-type: none"> Not well-studied Toxic aluminum ions can migrate into food product and cause alterations in product quality if not enamel coated⁴ More expensive than other packages
Tinplate cans	<ul style="list-style-type: none"> Protection from oxygen and light Semi-good resistance to mechanical damage³ Used in retail (0.25 - 5 L) Suitable for lithographic labeling⁵ Lightweight and compact Recyclable and eco-friendly 	<ul style="list-style-type: none"> Reusing tinplate packages can lead to corrosion as well as release compounds that accelerate oxidative reactions, thus leading to a shorter shelf life for olive oil (4 - 5 months) compared to using new cans (about 1 year)⁶ Some studies showed olive oils in tinplate cans were less stable than those stored in clear PET or clear glass containers⁷ Low consumer acceptance because most consumers judge oil by color and absence of turbidity⁸
Stainless steel	<ul style="list-style-type: none"> Mostly used for storage tanks and oil tankers which are used for the transportation of olive oil⁵ Excellent protection from oxygen, light, humidity and microorganisms¹ 	<ul style="list-style-type: none"> Heavy Expensive for commercial packages

	<ul style="list-style-type: none"> Highly resistant to mechanical damage and corrosion³ Reusable, recyclable, & eco-friendly 	
PET (polyethylene terephthalate)	<ul style="list-style-type: none"> Extensively used in beverage and food containers Better than PVC and PE for olive oil⁵ UV absorbers can be added to the plastic matrix to help prevent light penetration,⁴ and oxygen scavengers can be added to prolong shelf life¹⁰ Good resistance to mechanical damage³ Clear PET allows consumers to observe oil color Lightweight Inexpensive Recyclable, economical, & eco-friendly 	<ul style="list-style-type: none"> Reusing is not recommended because toxic component bisphenol A (BPA) might be released during reuse process¹¹ Clear PET allows light to penetrate thus accelerating oxidation⁴ A porous material thus permits the penetration of humidity and gases¹
PVC (polyvinyl chloride)	<ul style="list-style-type: none"> Popular in many countries, e.g. Greece, Italy, and France¹² Good protection from oxygen Moderate resistance to mechanical damage³ Adaptable to all types of closure Suitable for personalized design features¹³ Lightweight Inexpensive Recyclable, eco-friendly 	<ul style="list-style-type: none"> Vinyl chloride monomers (VCM), dioctyl phthalate (DOP), and dioctyl adipate (DOA) can migrate into oil during storage, so PVC should not be used without a coating, which is usually polyvinylidene chloride (PVDC)^{1,5} Bad protection from light Has been supplanted by PET¹ PVC bottles are a contaminant to PET bottle recycling, thus its recycling is controversial¹⁴
PP (polypropylene) PS (polystyrene) PE (polyethylene)	<ul style="list-style-type: none"> Good resistance to mechanical damage³ Inexpensive Lightweight Recyclable, eco-friendly 	<ul style="list-style-type: none"> Not suitable for olive oil storage due to high oxygen permeability¹⁵ PS leads to the least-stable olive oil among plastic materials¹⁶
Coated paperboard (e.g., Tetra-Brik®)	<ul style="list-style-type: none"> Used in some Mediterranean countries. Greater protection from oxygen and light than glass and plastic containers, significantly prolongs shelf life up to 2 years,¹ efficient in maintaining antioxidants¹⁷ Allows producers to have efficient logistics, lower possibility of rupture during transportation¹ Suitable for lithographic labeling Lightweight Inexpensive Recyclable, economical and eco-friendly 	<ul style="list-style-type: none"> Not widely used Low consumer acceptance because most consumers judge oil by color and absence of turbidity⁸ Non-reusable
Bag-in-box	<ul style="list-style-type: none"> Similar advantages as coated paperboard, though more durable Becoming more common and popular, especially for food service sectors in the US Lightweight Inexpensive 	<ul style="list-style-type: none"> Similar disadvantages as coated paperboard The type of plastics used in the bag can impact shelf life Has not been studied in literature

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