On Filtration

A response to the UC Davis Olive Center report

In October of 2015 the UC Davis Olive center produced a report on the practice of filtration. It was a work based on compiling and processing literature on the subject. No field tests were done by the Olive Center or the writers of the paper.

I'd like to present a constructive criticism to that report in the spirit of a necessary discussion on the subject for I consider it a key part of quality and shelf life in EVOO.

Moisture content as defined by the International Olive Council

The IOC has identified that in order to guarantee durability, EVOO needs to be lower than 0.20 % in its water content. This can be assessed with a simple lab analysis or with the proper equipment at the mill. Most olive oils, right after they're made, have a water content of 0.40%-0.50%. Thus, something has to be done in this regard if a good shelf life from harvest to harvest is expected.

Once this was understood, different filtration systems were put into practice. Not of all them were successful.

The first attempts at filtering were often faulty. Unfiltered olive oil was kept in tanks and filtered as bottled. This was actually counter-productive, since implied mixing back the sediments that were in the bottom (which exists even after racking) with the cleaner olive oil on the upper levels of the tank.

And most importantly, that did not prevent all the degrading processes that take place when water content is higher than 0.20% (enzymatic action/ hydrolysis, oxidative degradation – of lipids and polyphenols- and fermentative activity from sediments carrying bacteria, sugars, yeast, protein, etc.). The same can be said about racking and when unfiltered oil is kept in conical tanks that get rid of most sediments through a valve in the bottom that collects them.

So far, best results were achieved when filtration takes place immediately (good results are still achieved when filtration happens within 24 hours) and with the proper equipment.

Here it comes my first objection to the report: it generalizes filtration. While they identify several methods, the conclusions are presented as if any type of filtration would produce those results. This is not valid both for the positive and negative aspects noted in the report.

I'm going to limit myself to what I studied and practiced for several years: filtering with cellulose paper, both with rolls and with a plate filter.

This type of filtration aims at shelf-life (decreasing moisture and hygiene of the olive oil) and at quality as well (improving organoleptic characteristics).

Backing my own practice, I based this article on a paper recently produced in Florence (1) by a group of researchers, olive oil tasters and producers linked to the Laboratory of Chemistry of the Florence Chamber of Commerce, the University of Florence and published by the European Journal of Lipid Science and Technology.

On my practical experience

We've been using two filters specifically designed for olive oil filtration.

The first one, the filter "Più verde" ("Greener" in Italian) consist on two rolls of cellulose paper (one with smooth surface, the other one rough surface) that go together around five plates/serpentines, using a pump and then gravity. Given that the amount of paper the olive oil runs through is rather small and thin, this is an excellent filter for catching sediments though not enough for removing humidity.

It has been designed to filter "in continuum", as the olive oils leave the final separator or the decanter, depending on the mill.

A pre-filter made of 3 vertical stainless still cartridges (with holes of 0.50, 0.25 and 0.05 microns) was tested and proofed useful to retain sediments and therefore diminish paper use/waste. Given the amount of olive oil produced at our facility we discontinued the use of the pre-filter for practical reasons (mostly labor costs and pace of production) even when we had good results in terms of filtration itself and for reducing the use/cost of paper.

The filtration process gets completed when the oil is run through approximately 40 (this number can be less, according to what is needed, by removing some plates), square (40 cm x 40 cm) cardboard (cellulose) filter plates. One side of them is smooth and the other one rough.

This second filtration removes the smallest sediments and takes care of humidity, lowering water content drastically. This last passage is ideally done right after or the following day after the first filtration. Since a first filtration took care of the biggest sediments, one setting of paper filter goes a long way filtering around 750 gallons, depending on cultivar and temperature (colder olive oil slows the process and consumes more paper).

The ideal temperature to work with is between 17C-26C (62-78F).

Once filtered, the oil is ready to be storage or bottled, no further need for racking (which, by the way, it's also has costs and also brings oxygenation).

About the UC Davis report

Regarding some statements in the report by UC Davis on supposedly negative effects of filtration:

On oxygenation and sediments

1) While is true that there's some oxygenation and even a degree of emulsion that goes along with filtration, these are a minor impact given the benefits and protection filtration offers.

2) The report also says that filtration decreases stability due to the removal of suspended solids. Attributing a positive value to those solids is, at least, a debatable when not a questionable idea. Sediments have a clear decomposing action. They're vehicles for droplets of vegetable water, air,

mold, yeast, sugars, proteins, mucosae, microbes, fungi: “The water and suspended particulates also contain microorganisms, such as bacteria, yeasts and mold (2,3), which directly contribute to the transformation of the nutritional component of the oil. These micro-organisms may contain enzymes responsible for the hydrolysis of triglycerides (15), namely lipase, enzymes responsible for fatty acid oxidation (10), peroxidase, and those responsible for the degradation of phenolic compounds, namely b-glycosidase, esterase, and polyphenol oxidase (4). It should be noted that water must be present for enzyme activities (4).

In fact, after six months of storage, FFA is higher in unfiltered oils whereas is stable in filtered ones: “After 6 months of storage, the difference is roughly 0.1% and became significant. Lipases (NA- oxidation of the lipids) act in the interface between water and oil with the following mechanism: the hydrophobic part of the enzyme bounds with the oil, whereas the active site aligns with the substrate and severs the ester bounds of the triglycerides (5). Hence, the free fatty acids increase is probably due to the water content of cloudy oils, which allows lipase enzymes to hydrolyze triglycerides during the storage period. These results are in accordance with the work of Fregapane et al. (6), where they report that filtration reduced the rate of hydrolysis of the triacylglycerol matrix” (1).

Sensory analysis confirms this as the evolution of unfiltered olive oils is that of a loss of vitality first (diminished bitterness and pungency due to polyphenol oxidation), then higher viscosity, with oxidation manifesting itself as a greasy mouth feel.

Unfiltered olive oils get faster the “rough/oxidized” defect, precursor of rancidity.

Oxidation can happen for different reasons (low ratio of oleic acid vs linoleic and other acids, lack of phenols, photo-oxidation, etc.). In this case it’ll come from the oxidative processes brought by enzymatic reactions in a too humid media as unfiltered olive oils are (hydrolysis and oxidation of lipid and phenols).

This will be more or less perceptible depending on other factors, as original health of olives prior to milling, milling temperatures, type of equipment and cultivars. Nevertheless, unfiltered olive oils, including the ones of cultivars with a high polyphenol count, will be more prone to this greasy mouth-feel evidencing some degree of oxidation.

The words used in Italian and Spanish are quite interesting in terms of describing oil which have suffered oxidation: “grossolano” and “basto”, both meaning “coarse”. These oils often leave a greasy film in the leaps of the taster, being this a major sign of oxidation.

On polyphenol loss due to filtration

3) The report correctly points that there’s a reduction of water-soluble phenols (tyrosol and hydroxytyrosol) when filtration takes place. Then, it assumes that this will reduce shelf-life.

   While it’s true that filtration implies the loss of some water-soluble phenols (7-8%) this is altogether an insignificant loss, offset by the gains filtration brings. This is so because not all phenols are equal in their anti-oxidant action. Water soluble phenols are the weakest ones and more prone to decay. To understand this (and other important consequences of polyphenol incidence), one has to understand the higher value of phenols in its primary/original form (oleoeuropein and ligstrosides) and the lesser value of phenols that are secondary products/derivatives of them as hydrosol or hydroxytyrosol.

   Filtration provides for a serious protection to the oil-soluble polyphenols (oleoeuropein and ligstrosides) against oxidation triggered by enzymatic reactions enhanced by water. These phenols are the ones really in charge of anti-oxidative action: “Other works pointed out that a reduction in the total phenolic content [7] or in certain phenolic alcohols [8] could occur immediately as a result of water removal. In the present work, the total phenolic content was 337 mg/kg in cloudy oil, and 313 mg/kg in filtered. This difference is not significant at the paired t-test. Over time, filtration affects on both total phenolic content and each phenolic compound. The effect was particularly pronounced for phenolic alcohols, namely tyrosol and hydroxytyrosol, which content in cloudy samples reaches values up to an order of magnitude greater than that in filtered oils. The increase in phenolic alcohols in cloudy oils over time is a consequence of the degradation of the secoiridoidic fraction [9] (oleoeuropein and its derivatives, and derivatives of ligstrosides), which decreased in cloudy oils (…) Regarding oleuropein derivatives, there was a significant increase in hydroxytyrosol and a concomitant decrease of dialdehydic form of decarboxymethyloleuropein aglycones in cloudy oil. On the other hand, in filtered oil, hydroxytyrosol did not change significantly, whereas there was a significant increase in oleuropein aglycones similarly to cloudy oils. The different changes in filtered and cloudy oils of oleuropein derivatives could be explained by the deglycosilation of oleuropein, due to the action of b-glucosidase, mediated by water [4]. The formation of tyrosol and hydroxytyrosol is due to the rupture of the ester bond in the dialdehydic form of decarboxyme- thylligstroside aglycon and the dialdehydic form of decar- boxymethyloleuropein aglycon, respectively. This is a hydrolytic reaction, favored by the presence of water [4]. For this reason, the degradation of phenolic compounds is more pronounced in the cloudy oils, in which there was a significant increase in tyrosol and hydroxytyrosol, and a concomitant decrease in the dialdehydic form of decarboxymethylligstroside aglycon and the dialdehydic form of decarboxymethyloleuropein aglycon. As a consequence of these phenomena, the nutritional value of unfiltered oils rapidly decreases, whereas the filtration allows to maintain a high nutritional value for the filtered oils over time (1).

Filtration, positive attributes and sensory analysis

4) The UC Davis study also says that filtration “Eliminate desirable compounds that affect the aroma of the oil”.

Here is what this recent study done in Florence says about the chemical side of this issue: “On the other hand, the volatile fraction was influenced by filtration. Table 2 shows the mean values of some volatile molecules, selected on the basis of the study by Kalua et al. [10]. It has been established [11,12] that the most abundant volatile compound related to the LOX pathway is E-2-hexenal. The content of this molecule, and that of Z-3-=hexenal, is higher in just filtered oils than in cloudy oils. Over time, these aldehydes significantly decreased in cloudy oil, whereas they remained constant in filtered oil. As the fruity attribute is closely linked to these molecules [11], we conclude that filtration enhances this sensory attribute. On the other hand, the alcohols E-2-exenol and hexenal, and the ester E-2-hexenyl acetate were more abundant in cloudy oils. This phenomenon could be explained by the inhibition of enzyme activity of alcohol dehydrogenase and alcohol acetyl transferase due to the removal of water during filtration, which, over time, preserves C6 aldehydes known to be responsible for the "green" aroma [13]. The concentration of ethyl acetate, considered to be a winey marker [38, 42] was consistently higher in cloudy oils than filtered oils; moreover, it only increased over time in the case of cloudy oils (1)".

5) Another negative point according UC Davis: "Decreases positive attributes (fruitiness, bitterness, pungency)."

   This statement provides for an interesting discussion that will address the previous point as well. Aside from the chemical data offered by the study in Florence, sensory analysis can be of help in this case, since we're discussing exactly that. And here is where a some of these studies cited by UC Davis are outdated. The only way to acknowledge if filtered oils fare better or worse than unfiltered ones in terms of organoleptic virtues is by comparison in panel tasting sessions. Proper filtration and oils of true excellence are a very recent phenomena and literature falls short on this type of studies, aside from the study done in Florence (and this one clearly favored filtered oils as storage-time passed by).

   Since these filtered olive oils of high quality are a rather new thing, there's no surprise that the European panels in contact with them (the majority of them in Italy and some in Spain), are the ones abler to more rapidly identify the virtues of these in contrast to the old fashion characteristics of unfiltered ones. This trend fell already onto panels trained above all for detecting quality (or the absence of it), not just for EVOO certification. These panels would appreciate specific, central key elements in the evaluation of EVOO such as freshness, cleanliness, neatness, structure, durability, greenness. Since filtration is functional and synergetic to these characteristics, tasters familiarized with these concepts and values can acknowledge the benefits of filtration more easily than tasters who have not been exposed to this approach.

In California, 98%-99% of the EVOO produced is unfiltered and therefore, local tasters have not had much chances of learning about discriminating one lot from the other. Interestingly enough, the practice of filtration gained serious traction in Italy when blind tasting sessions consistently favored filtered olive oils.

Filtered oils have a quite distinct texture, leaner, cleaner and crispier than unfiltered ones.

Filtration removes non-olive oil matter and thus allows for a neater experience of positive attributes.

Tasters trained to distinguish filtered vs unfiltered become sensitive to the sensory aspects of the non-removed vegetable water while tasters unaware of it tend to compute its presence positively, as a "harmonizing" factor. In reality, what the remnants of vegetable water do is numbing flavors while they bring a viscosity that Italians describe as "pastosità" (doughy-ness).

It's worth noting that for many years, some tasting schools (associated with areas where above all mass-marketed olive oil was produced and not much quality olive oil) denied that texture was an element of olive oil tasting. In fact, the "rough" defect is a recent addendum by the IOC to their tasting sheet. This also shows how sensory analysis of EVOO is an evolving discipline which has been changing in the recent years along with newer milling technologies being available.

Bitterness get rounded up with filtration, contributing to something some experts in Italy call "olive bitterness" (though achieving this requires optimal ripeness and proper milling as well). The latter is quite different from bitterness from vegetable water, wood, debris, or tannic, harsh bitterness.

The removal of waste water and sediments allow for flavors to be sharper and overall the filtered olive oil gains in elegance.

The same goes for the aromas. In order to appreciate that, tasters need to be trained in discriminating strictly aromas coming solely from olives from aromas and odors (even pleasant ones) coming from other sources. This applies to decaying processes as oxidation, that goes producing, momentarily, over-ripe fruit aromas that can have some intensity for a while.

The effect filtration has on some cultivars as Mission and Manzanillo (particularly when working with older trees), is remarkable, helping to reduce some rustic sides of the olive oils coming from these varieties. The same can be said for robust cultivars as Coratina, Picual or Moraiolo.

Finally, and even this being not a proof of anything, the fact that the vast majority of winners of European competitions (winners also of the international section of US competitions) are filtered oils is something to ponder on (14).

6) The next two points of UC Davis are the more curious ones. They said that filtration diminishes the green color of the olive oil.

I believe that the confusion originates when filtration was done before bottling and sediments were remixed with the olive oil. I imagine that some papers were produced after those experiences.

Suspended particles have some chlorophyll though this rapidly turns yellow (meaning it has oxidized). Thus, the removal of sediments only removes some green-ness in the moment of filtration though guarantees a greener oil over time.

The only thing to consider about this issue is that removing the floating particles and sediments leaves the filtered oil more vulnerable to photo-oxidation (the particles screen the light a bit).

As we well know, this is to avoid in any case with both filtered and un-filtered olive oils. Proper storage will take care of this.

It's also true that after filtration olive oil is more transparent and glowing, having altogether a different kind of green. Nevertheless, not less green (rather the opposite, since sediments tend to brownish the color of the olive oil). One could wonder why this Italian filter we use is called "Greener" if using it would produce the opposite.

Photos can be seen at the end of this article.

It's fair to mention that the report acknowledges some studies that see filtration, or aspects of it in a positive fashion. It lists some important benefits as diminishing moisture, increasing stability, diminishing FFA, decreasing hydrolysis and therefore extending shelf life, and that eliminates undesired compounds that affect aromas. While all these is true, each positive effect is presented with an equal or greater negative effect, giving overall a negative view of the practice.

Filtration would be a relative inexpensive step forward for the segment of the Californian industry aiming at having premium quality EVOO.

And more importantly, it'd be critical for the vast majority of Californian olive oils in terms of improving shelf life and stabilizing positive attributes, something that has not been discussed/addressed much in our industry.

Filtration has its downsizes (labor costs, loss of oil trapped in the filters, cost of the equipment, time-consuming) though it has proved so far, the best method to reduce the moisture/water content below the IOC standard of 0.20% (it goes from 0.44%-0.22% to 0.07%-0.10%) while improving the organoleptic characteristics of EVOO.

In a recent visit to Italy I met with a group of producers, researchers and tasters, some of them authors of the study where most of the quotations in this article come from. When I mentioned the UC Davis report to them their comment was that nobody making premium EVOO in Italy questions filtration any longer. That's an outdated discussion. The current discussion is about how to filter, improvements in filter equipment, etc.

With this I hope to bring about a friendly discussion on the subject. My experience has been so enthusiastically positive that I naturally want to share it, with my best wishes for our growing industry.

Summary

Filtration is the more effective method known so far to reduce water content in olive oil below 0.20%, as recommended by IOC.

Not all filtration methods produce the same result.

Filtration has to happened immediately after olive oil is made.

Oxygenation is a minor negative aspect of filtration offset by the many positives it brings.

Suspended solids are to be removed, there's no significant positives associated with their presence in olive oil.

While is true that there's a loss of water-soluble phenols this is a minor loss, given that the anti-oxidant activity of these are marginal next to the action of fat-soluble phenols, which filtration protects.

Filtration does not remove any desirable aromas nor diminishes positive attributes. On the contrary, by removing non-olive oil matter that has a negative evolution, filtration contributes to sensory positive attributes and preserves them for longer.

There's no significant decrease of chlorophyll content, aside for the chlorophyll present in sediments, the one more prone to rapid oxidation, a small amount in any case. Unfiltered olive oils are not greener by any means.

Filtration reduces moisture, extends shelf-life, impedes hydrolysis and delays oxidation of lips and phenols.

Besides its down sides (costs, time and labor expenses, loss of oil trapped in filters and investment in equipment) filtering is such a positive practice and a key part in the production of quality olive oil, as it has been assumed by most premium brands in Europe.

Pablo Voitzuk

(1) Martina Fortini, Marzia Migliorini, Chiara Cherubini, Lorenzo Cecchi, Lorenzo Guerrini, Piernicola Masella and Alessandro Parenti. Shelf life and quality of olive oil filtered without vertical centrifugation. -
(2)Ciafardini, G., Zullo, B., Microbiological activity in stored olive oil.
Int. J Food Microb. 2002,75, 111–118.
(3) Ciafardini, G., Zullo, B., Iride, A., Lipase production by yeasts from extra virgin olive oil. Food Microb. 2006,23,
(4) Cecchi, L., Migliorini, M., Cherubini, C., Innocenti, M.,Mulinacci, N., Whole lyophilized olives as sources of unexpectedly high amounts of secoiridoids: The case of three Tuscan cultivars. J. Agric. Food Chem. 2015, 63, 1175–1185.
(5) Brockerhoff, H., in: R. G. Jensen (Ed.), Lypolytic Enzymes,
Academic Press, New York 1976, pp. 25–125.
(6) Fregapane, G., Lavelli, V., Leon, S., Kapuralin, J.,Desamparados Salvador, M., Effect of filtration on virgin olive oil stability during storage.
Eur. J. Lipid Sci. Technol. 2006, 108, 134–142.
(7) Koidis, A., Boskou, D., The contents of proteins and phospholipids in cloudy (veiled) virgin olive oils. Eur. J. Lipid. Sci. Technol. 2006, 108, 323–328
(8) Lozano Sanchez, J., Segura-Carretero, A., Fernandez -Gutierrez, A., Characterization of the phenolic compounds retained in different organic and inorganic filter aids used for filtration of extra virgin olive oil. Food Chem. 2011, 124, 1146–1150.
(9) Brenes, M., Garcıa, A., Garcıa, P., Garrido, A., Acid hydrolysis of secoiridoid aglycons during storage of virgin olive oil. J. Agric. Food Chem . 2001, 49, 5609–5614.
(10) Kalua, C. M., Allen, M. S., Bedgood, D. R., Bishop, A. G.,et al., Olive oil volatile compounds, flavour development and quality: A critical review. Food Chem . 2007, 100, 273–286.

(11) Di Giacinto, L., Di Loreto, G., Di Natale, C., Gianni, G., et al., Caratterizzazione analitica degli attributi sensoriali degli oli vergini di oliva. Project final report. Camera di Commercio di Firenze. 2010.
(12) Tamborrino, A., Clodoveo, M. L., Leone, A., Amirante, P.,Paice, A. G., in: Preedy, V. R., Watson, R. R. (Ed.) Olives and Olive Oil in Health and Disease Prevention, Academic Press, San Diego 2010, pp. 77–83, ISBN 9780123744203.
(13) Angerosa, F., Servili, M., Selvaggini, R., Taticchi, A., et al., Volatile compounds in virgin olive oil: Occurrence and their relationship with quality. J. Chromatogr. A 2004, 1054, 17–31.
(14) Some premium EVOOs from Europe, consistent award winners: Dievole, Altomena, Balduccio, De Carlo, Intini, Caputo, Torre Bianca, Olio della Madonina, Fattoria Ramerino, Laudemio, Franci, Fonte di Foiano, Castillo de Canena, Melgarejo, Marqués de Grignón, Crudo. From California: Apollo, Katz, Isern, Saltonstall, Moonshadow, Pacific Sun.
(15) Capella, P., Fedeli, E., Bonaga, G., Lercker, G., Il Manuale degli Oli e dei Grassi, Tecniche Nuove, Milan (Italy) 1997.