Minimising water consumption in olive oil separation

In a nutshell

Summary				
During the separation (also known as clarification or polishing) of the olive oil from the remaining fine particles and water, best practice is to use a vertical centrifuge that minimises the use of water. The quantity of water used should be kept to the minimum amount required to achieve the desired final olive oil composition				
Target activities				
All food and beverage manufacturing	Processing of coffee	Manufacturing of olive oil	Manufacture of soft drinks	Manufacture of beer
Production of meat products	Manufacture of fruit juice	Cheese making	Manufacture of bread, biscuits and cakes	Manufacture of wine
Applicability				
This best practice is applicable to all olive oil manufacturers. The amount of water needed in the separation phase is highly dependent on the quality of the oil coming from the decanter.				
Environmental performance indicators				
• Water use in olive oil separation (l) per weight (tonnes) of olives processed or per unit volume (l) of olive oil manufactured				
Benchmarks of excellence				
• Water used in olive oil separation is less than 50 l (5 %) per 1,000 l of olive oil manufactured				

Description

Olive oil is the oil obtained solely from the fruit of the olive tree (*Olea europaea L.*). It is a key ingredient in the Mediterranean diet, renowned for being healthy, although its popularity has now expanded beyond its area of origin: the Mediterranean basin.

Olive-growing and olive oil production are very important within the EU's agricultural and food sectors. The European Union is the largest olive oil producer; in the year 2011/12 Spain, Italy and Greece alone accounted for 70% of global olive oil production (International Olive Oil Council, 2013). In terms of area, in 2012 olive farming (for both olive oil and table olives) covered 23% of agricultural land in Greece, 7% in Italy and 11% in Spain[1].

Due to the growing popularity of this product over the last two decades, olive growing has become more intensive, using an increasing amount of land and resources. Olive oil production also requires large amounts of water. This is particularly problematic given that it is concentrated in countries and areas where water resources are scarce (European Commission, 2010).

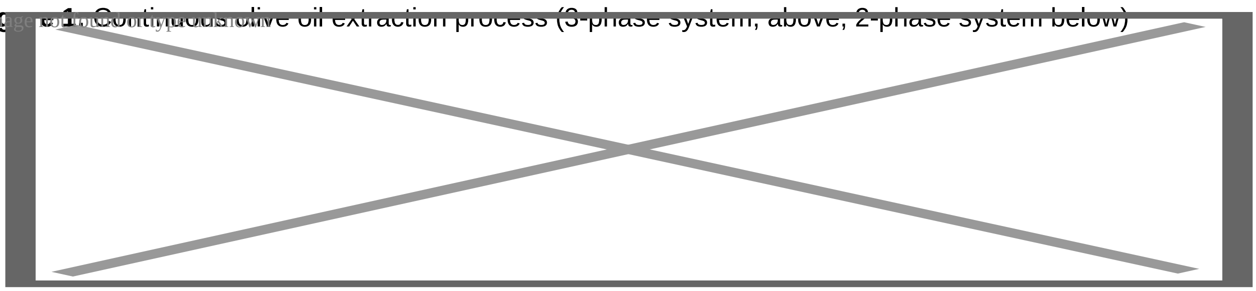
The large volumes of water used for processing result in a significant amount of contaminated waste water. Its management is regulated in European olive oil-producing countries given that uncontrolled disposal of such liquids causes phytotoxicity, water and soil pollution (Olèico$^+$, 2012). Although the waste water from different types and stages of processing varies, it can be described with the following general characteristics (Tsagaraki, 2007):

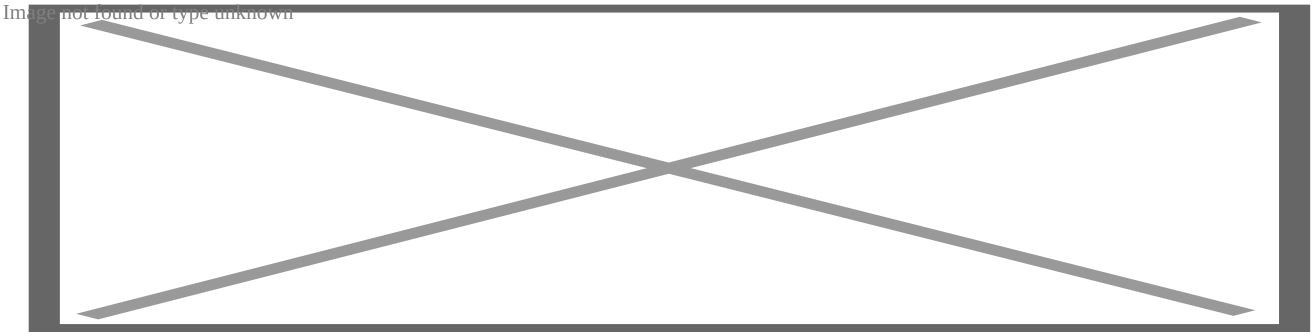
- strong foul odour,
- high degree of organic pollution, with COD values up to 220 g/L,
- slightly acidic pH (between 3 and 5.9),
- high content of non-easily biodegradable polyphenols which are toxic to most microorganisms.

This best practice focuses on the final stage of olive oil processing: separation (also known as clarification or polishing). The outline of a continuous process for olive oil production is shown in Figure 1; the traditional press can also be used for primary extraction. Olives are picked by hand or by automatic means, contaminants such as leaves, stones and soil must be removed through the de-leafing and cleaning stages. The olives must then be crushed to liberate the oil from the fruit's cells. The malaxation stage, which results in liberating more oil from the flesh, is necessary to increase the yield of extraction. The olive oil is firstly extracted from the paste by mechanical means; pressure, centrifugation and percolation technologies are available. Horizontal decanters are the most common choice of extraction machinery in Europe (Di Giovacchino, 2002).

The final processing stage, as mentioned above, is the separation of the olive oil from remaining fine particles and water. This is required to 'clean' the oil of remaining impurities in order to produce higher quality oil. This is usually done through centrifugation; a vertical centrifuge with a rotatory speed of 6,500-7,000 rpm is used for this process (Di Giovacchino, 2002).

Figure 1 Continuous olive oil extraction process (3-phase system, above; 2-phase system below)





Source: GEA Westfalia Separator Group (nd.)

In the centrifuge, substances with different densities separate along the radial direction. The heavier substances, in this case the fine particles, move away from the centre and are collected in a container, as shown in Figure 2. Water, which has a medium density, forms the middle stratum and drains from the centrifuge. The oil, which is the lightest substance, stays in the centre from where it is pumped out (GEA Westfalia Separator Group, nd.).

Warm water is generally added to the previously extracted oil. The water improves the separation of the fine particles from the oil by creating a larger phase separation within the centrifuge. The amount of water required is a fine balance between better removal of the fine particles and preservation of polyphenols within the oil. Polyphenol content is very important for oil quality. Polyphenols are water-soluble; therefore, the addition of water for centrifugation results in reduced content following this process. However the water improves the removal of fine solids (GEA Westfalia Separator Group, 2014, pers. comm.).

The centrifuge must be cleaned periodically to remove the accumulated solids. Machinery with either automatic or manual cleaning is available. If cleaned manually, the centrifuge has to be stopped and cleaned with water; this takes approximately one hour (GEA Westfalia Separator Group, 2014, pers. comm.). Modern technology automatically discharges the accumulated solids whilst in operation (in just few seconds) by automatically opening peripheral holes in the drum (Di Giovacchino, 2002). Some oil can be lost during this operation; however, this is limited in the presence of water which acts as a phase separator between the soil and oil phases (GEA Westfalia Separator Group, 2014, pers.comm.).

The literature gives varying data with regards to the amount of water used during this separation stage. This will depend on the quality of the oil after extraction, the amounts of impurities present and the centrifuging machinery. In the 1990s, 300 litres of water were added per 1000 litres of olive oil produced (Pieralisi, 2014, pers. comm.). More recent literature provides the following figures:

- between 15% and 50% of the oil volume (Regional Activity Centre for Cleaner Production, 2000).
- an industry source reported that the typical amount of water used in 2014 was 200 litres of water added per 1000 litres of oil (20%) (GEA Westfalia Separator Group, 2014, pers. comm.).

Figure 2: Oil separation through a vertical centrifuge

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Image not found or type unknown

Source: GEA Westfalia Separator Group (nd.)

Minimisation of added water has been identified as best practice for this stage of olive oil production. This must be done mindful of the final quality of the olive oil and the efficiency of fine solids removal. This is particularly important given the increasing demand for high quality olive oil (Mili, 2006). Improved technology and research have resulted in lower quantities of water being needed for effective impurity removal (Borja, 2006). According to different sources, the use of water can be reduced down to between 100 litres and 50 litres of water per 1000 litres of oil (10% to 5%) all the way to using no water (GEA Westfalia Separator Group; Pieralisi, 2014, pers.comm.). This will depend on the quality of the oil following extraction.

The water is used to aid the removal of impurities in the oil and does not form part of the end product but instead generates waste water. Consequently, the lower the amount of water used, the lower the amount of generated waste water requiring treatment. Several methods to manage such wastes exist, depending on the country of production and the size of the olive oil producer. In Spain it is considered best practice to treat this water from the separator by mixing it in the "repasso" phase with the pomace waste arising from two-phase decanters used in the first extraction, and then dry it in evaporating lagoons. In other countries the solids from the used olive wash water are removed through natural sedimentation and the cleaned water can then be recycled in the initial olive washing process (GEA Westfalia Separator Group, 2014, pers. comm.).

[1] These figures were calculated using the Agriculture, forestry and fisheries data from the Eurostat database. Available at: http://epp.eurostat.ec.europa.eu/ [Accessed 23 October 2014]

Environmental benefits

This best practice focuses on the reduction in water used during the separation phase of olive oil production. Therefore, the obvious environmental benefit is that of reduced water consumption. By looking at the data above, the reduction in water use specifically related to the vertical centrifugation of oil will vary according to the initial amounts of water used and the quality of the incoming oil, which dictates the minimum water requirement so as not to compromise the quality of the product. The highest water use cited in the literature is 50% (500 litres of water per 1000 litres of oil) (Regional Activity Centre for Cleaner Production, 2000). If this is reduced to 5% of the oil quantity, it will result in a 90% reduction in the vertical centrifugation step. However, it was reported that the typical amount of water used in 2014 was of 200 litres per 1000 litres of oil (GEA Westfalia Separator Group, 2014, pers. comm.). Therefore reducing this to 5% will result in water savings in this stage of olive oil production of 75%.

This aspect is particularly important as water in the major oil-producing countries is scarce. For example, Andalucía and Puglia, the largest olive oil-producing regions in Spain and Italy respectively (Eurostat, 2014), are both shown as 'over-exploited' according to the water stress indicator presented in Figure 3. Major producing countries, including Greece, Italy, Spain, and Portugal, but also Morocco, Syria, Tunisia and Turkey outside of Europe have large areas classed as 'highly exploited' or 'over-exploited' (see Figure 5.4).

Reduced water use also results in a reduction in waste generation from the separation process and therefore lower waste water treatment needs. Water added to the oil for centrifugation is used as a means to improve the removal of water (1% to 10% water content) and fine particle impurities still present in the oil following extraction (Pieralisi, 2014, pers. comm.). Therefore, this water plus the removed impurities all result in waste water which must be treated.

Figure 3: Water Stress Indicator (WSI) in major basins

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Source: UNEP (2008) from Smakhtin (2004)

Side effects

The waste water from vertical centrifugation can be recycled in the olive washing or added into the “repasso” (the solids exit phase of the two phase decanter) before the pomace is centrifuged again or dried. When lower amounts of water are used, lower amounts of waste water will be generated meaning less of this will be available for recycling. Hence, other water sources must be found for this purpose.

Applicability

It is reported that the majority of olive oil producers make use of vertical centrifugation technology for clarification purposes (Pieralisi, 2014, pers. comm.). The amount of water used will depend on the quality of the oil coming from the decanter. This can depend on a number of factors, including the amount of oil processed and the quality of the olives. The amount of water can be minimised when the oil contains a low concentration of water and fine particles, thus not affecting the final product quality. In all cases, the quantity of water used should be kept to the minimum amount required to achieve the desired final composition.

Economics

The aim of this best practice is to minimise the amount of water used during the final clarification in olive oil processing. A clear economic saving is that of water costs. In terms of machinery, no costs will be incurred as different technologies are not required; vertical centrifuges are already owned and used by most olive oil processors (Pieralisi, 2014, pers. comm.).

Reducing water inputs also results in reduced waste water outputs. Therefore, in mills where these are treated chemically or biologically, the cost of such treatments will be lowered given that the amount of waste is also reduced.

Driving forces for implementation

Water scarcity is an increasingly important issue in major olive oil-producing countries. In these regions, the major environmental problems associated with olive oil mills are related to water consumed during the production process (Mili, 2006). For this reason, reducing the stress on the water resources and consequently the environmental impact of olive oil production should be seen as a major driver.

Within Europe, around 4.6 million tonnes of olive mill waste water are produced each year, including the waste produced during the final separation of olive oil. This water is highly polluted and is expensive and difficult to treat, causing environmental concern (European Commission, 2010). A reduction in the generation of such waste and its environmental impacts should be considered a major driver to minimise the use of water during olive oil separation.

Historically, the treated waste water reuse in Greece, Italy and Spain has been very low. A study in 2007 (EUWI, 2007) stated that '*The treated waste water reuse rate is high in Cyprus (100%) and Malta (just under 60%), whereas in Greece, Italy and Spain treated waste water reuse is only between 5 % and 12 % of their effluents*'. Consequently, water reduction and the associated reduction in waste water generation should be seen as a major driver in these three countries.

Reference organisations

Examples of companies having implemented the measures described in this BEMP are:

- OleoAlgaidas SCA Villanueva de Algaidas
- Molino de Genil
- San FRANCISCO from Villanueva

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