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Research Note

Addition of a steel pre-filter to improve plate filter-press performance in olive oil filtration

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ABSTRACT

Olive oil is a turbid colloidal dispersion. The most common technique used to clear the oil is filtration. Among filter systems, plate filter-presses are used by small companies because the filters are cheap, and the technique does not impair the sensory and chemical traits of the olive oil. However, plate filter-presses have some disadvantages: their operating capacity is low, they require a lot of man power, and filter sheets trap part of the processed oil. It has been argued in the literature that they can retain minor compounds. Furthermore, there is a cost associated with their disposal. The impact of all of these issues could be reduced by the optimization of filtration cycles. Hence, a new processing arrangement was proposed and tested. This consisted of the insertion of a steel pre-filter into the system, which retained part of the suspension. Consequently, the plate filter-press only retained residual solids and water. The plate filter press with the added pre-filter was able to process about 1.8 times the amount of oil normally processed in a batch. Operative capacity was improved and the amount of oil trapped in the sheets was reduced. Furthermore, the number of the filter sheets required was almost halved, which also halves their purchase and disposal costs. A surface fouling mechanism is seen in the traditional filter press configuration, while in the new configuration particle retention is due to depth fouling. This change in the fouling mechanism demonstrates that the addition of a pre-filtration step leads to the more effective use of filter sheets.

1. Introduction

The turbidity of olive oil (OO) has been described as a dispersion/suspension system (Lercker et al., 1994; Koidis and Boskou, 2006; Kiosseoglou and Kouzounas, 1993; Bianco et al., 1998; Parenti et al., 2008). The solid particles that contribute to the turbidity come from the olive fruit. They range in size from around 5 μm to 60 μm (Koidis et al., 2008). Suspended amphiphilic chemical compounds and water form a colloidal association that has the physical structure of reverse micelles or lamelles (Papadimitriou et al., 2013), which gives OO its turbid appearance. The most widespread method used to remove this turbidity is filtration. Traditionally, plate filter presses have been used to filter OO and they remain important, despite other more recent and efficient techniques (e.g. cross-flow, described in Bottino et al. (2004)). One major problem with these devices is that they operate in batch mode, while another key issue is the optimization of filtration cycles. Optimized cycles offer better operating capacity; they reduce energy costs, minimize losses and the problem of the disposal of exhausted filter sheets (Peri, 2014). Furthermore, it has been argued in the literature that filtration aids are responsible for the hydrophilic retention of phenols and hence impair OO sensory traits (Lozano-Sánchez et al., 2011; Gomez-Caravaca et al., 2007). In general, plate filter presses are run by small companies that cannot afford to purchase other types of filters. Hence, in order to optimize the filtration cycle of plate filter presses, we designed and implemented a pre-filter made of steel, in order to separate the suspended solids from the water. Our solution was applied and tested in an industrial setting, in order to compare it with traditional plate filter presses.

2. Materials and methods

2.1. Plate filter press

A 0.4 m × 0.4 m plate filter press was used for the tests (Mori SNC, Italy). The device was equipped with eleven V8, clarifying, disposable filter sheets (Cordenons, Italy) made of cellulose and diatomaceous earth, with a total filtration area of 1.76 m^2. The

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technical specifications of the producer are: base weight 1050 g m^{-2}, 3.40 mm caliper, 12 μm nominal filtration rate, and water flowrate of 160 l min^{-1} m^2. This configuration was used in all tests, both by itself in the control (C) condition, and following the addition of the steel sieve in the test configuration (SC).

2.2. Steel pre-filter

Three sintered steel filter cartridges (sieves) were applied before the filter press. The nominal pore size of the sieves progressively decreased from 40 μm to 20 μm, to 5 μm. Each cartridge was cylindrical, 0.76 m high and 0.066 m in diameter, filtration surface of 0.157 m^2. The total cartridge area was 0.471 m^2. The total filtration area of the system was 2.231 m^2. Cartridges were washable and reusable. The pore size of the pre-filter was based on Koidis et al. (2008). The aim was to separate as much as possible of the suspended solids, while the cellulose filter sheets would retain the remaining water.

2.3. Trials

Operative performance was measured in five trials, during the November 2013 olive season, at Frantoio di Carbonile Ol. C.A.S. S.R.L. (Florence, Italy). In each trial a single quantity of OO was chemically characterized resulting within the normative limits for extra virgin olive oil for standard parameters (free acidity, peroxide value, K232, K270 and Δ*K*), whereas tocopherols range 192–218 (mg kg^{-1}) and biophenols range 327–420 (mg kg^{-1}). Humidity content resulted in the range of 0.13–0.430%, suspended solids 0.04–0.40%, and turbidity was ever higher than 1 (absorbance at 630 nm). The oil was filtered with, and without the pre-filter (Fig. 1). In both cases, the oil was taken directly from the decanter and immediately filtered, without vertical centrifugation. The filtration batch was defined as the quantity of OO that was filtered before the flow rate dropped below 1.5 l min^{-1}. This is the usual practice when 0.4 m × 0.4 m filter presses are used. The flow rate was monitored by measuring the weight of OO leaving the filter in 30 s; the corresponding pressure was recorded. Furthermore, OO losses were measured for both filtration systems. Losses were defined as the amount of OO trapped in the filter sheets; they were estimated by weighing the sheets before and after usage.

2.4. Chemical and physical analyses

The OO was characterized before and after filtration using the following chemical parameters: free acidity, peroxide value, K232, K270 and Δ*K*. This method is set out in European Commission Regulation EEC/2568/91 and subsequent amendments. International olive oil Council (2009) total and single biophenol content were recorded according to the method described in COI/T.20 Doc. N 29. Total tocopherols, were determined according to the method EN ISO 9936:2006. Turbidity of the OO was monitored through the measurement of absorbance at 630 nm (Parenti et al., 2008; Peri, 1983). The suspended solids content was determined according to the Italian Standard for Fat and Derivatives (NGD C7, 1976). The OO water content was measured using Karl Fisher titration. The water content of the filter sheets was determined by drying samples weighing 10 g to a constant weight at 103 °C. The oil content of the filter sheets was assessed using Soxhlet extraction. The solids retained by the filter sheets during filtration were assessed using a mass balance. Oil, water and net weight were subtracted from the gross weight of the sheet. The difference was defined as the retained solids content. The colour of the sheets after use was evaluated using L^*, a^* and b^* coordinate values that were measured using a Minolta Colorimeter CR-300 (Minolta Camera Co., Japan).

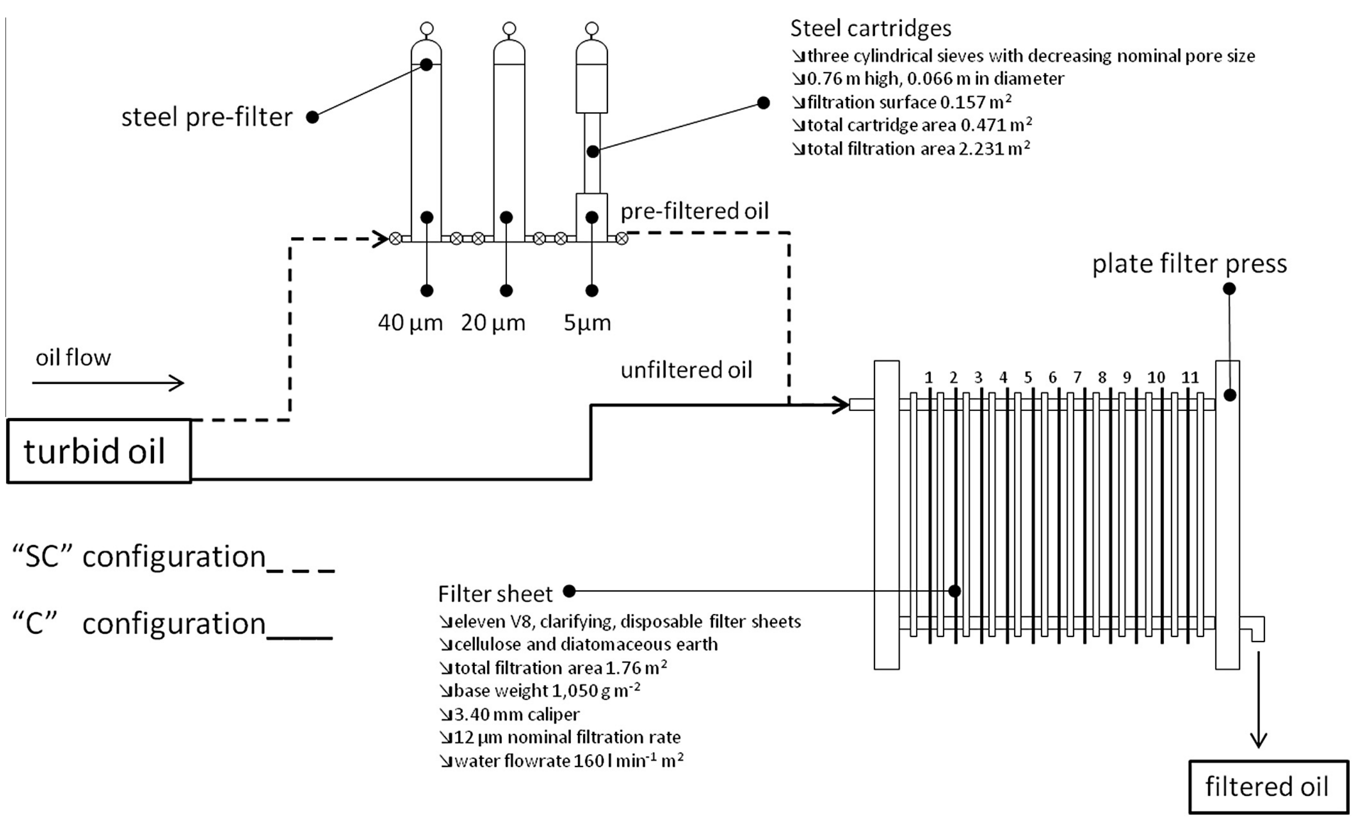

Fig. 1. Processing flowchart of the experiment. C is the traditional plate filter press, where the oil flow is sketched by the continuous straight line; SC is the plate filter press with the addition of a pre-filter, where the oil flow is sketched by the dashed line. Some technical specification of the filter are given in figure.