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Beyond the traditional virgin olive oil extraction systems: Searching innovative and sustainable plant engineering solutions

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ABSTRACT

The entire virgin olive oil (VOO) process has changed very little over the last 20 years. One of the essential challenges of VOO industrial plant manufacturing is to design and build advanced machines in order to improve the working capacity of the industrial plants and create more sustainable engineering solutions. Ultrasound (US) and microwave (MW) are emerging technologies that have already found application in the food industry. Yet, application in the VOO sector has been scarcely investigated. In order to ascertain if the mentioned emerging technologies are able to increase the environmental sustainability improving VOO extraction yields, two different treatments (US and MW) of olive paste were adopted in the VOO extraction process on a pilot scale plant. In these experimental conditions, the main parameters legally established (acidity, peroxide value, and specific extinction coefficients (K_{232} and K_{270})) to evaluate VOO quality were not affected by the US and MW treatments. Moreover US and MW processes reduced significantly the length of the malaxation and improved the extraction yield as compared with the control when the oils were extracted from the paste without malaxation. Results also prove that US technology was more sustainable than MW which appears as an energy consuming method in a pilot scale plant. Therefore the industrial application of these technologies could represent the first step toward the development of continuous new devices.

1. Introduction

The public's demands for adequate and sustainable quantities of good-quality food throughout the food chain stimulated the study and application of promising new and emerging food technologies (Helms, 2004). Ultrasound (US) and microwave (MW) are emerging technologies that have already found application in the food industry (Knorr et al., 2011; Galanakis, 2012; Li, Pordesimo, & Weiss, 2004; Malheiro, Casal, Ramalhosa, & Pereira, 2011) instead of the time consuming conventional processes. However US applications in the virgin olive oil (VOO) remain scarce (Clodoveo, Durante, & La Notte, 2013; Clodoveo, Durante, La Notte, Punzi & Gambacorta, in press; Jiménez, Beltràn, & Uceda, 2007) while MW has not been applied before in this food industrial sector.

Olive oil is a premium vegetable oil highly appreciated and consumed. It constitutes the main lipid source in the Mediterranean diet due for its organoleptic and healthy properties (Bedbabis, Clodoveo, Rouina & Boukhris, 2010; Apetrei, 2012; Romero-Segura, García-Rodríguez, Sánchez-Ortiz, Sanz & Pérez, 2012; Inarejos-García, Gómez-Alonso, Fregapane & Salvador, 2013). VOO can be consumed directly in its crude form or as food ingredient (Caponio, Summo, Clodoveo, & Pasqualone, 2008). In order to ascertain if the mentioned emerging technologies are able to increase environmental sustainability by improving VOO extraction yields, two different treatments (US and MW) of olive paste were adopted in the VOO extraction process in a pilot scale plant.

1.1. Conventional VOO extraction systems

Current systems for mechanical extraction of VOO defined as "continuous-type" are generally comprised of a continuous mechanical crusher (Fig. 1(4)) (Amirante, Clodoveo, Tamborrino, Leone, & Paice, 2010; Dugo et al., 2007), a batch malaxer (Fig. 1(5)) (Clodoveo, 2012) and a continuous horizontal-axis centrifugal separator (decanter) (Fig. 1(6)) (Amirante & Catalano, 2000; Amirante, Cini, Montel, & Pasqualone, 2001; Amirante, Clodoveo, Tamborrino, Leone, & Patel, 2010). The objective of the malaxation is to facilitate coalescence of oil droplets into drops of greater size, more easily separable by a centrifugation field, reducing the viscosity value of the olive paste and optimizing the separation of the oil inside the decanter. Malaxation actually represents the bottleneck of the continuous extraction process. At present, in order to assure continuity to the process, plural malaxing machines are set in parallel (Fig. 1(5)), with the burden of a heavy investment in plant engineering (Clodoveo, 2012). Actually oil mills, not equipped with plural malaxers arranged in parallel, operate discontinuously and do not fully exploit the working capacity of the metal

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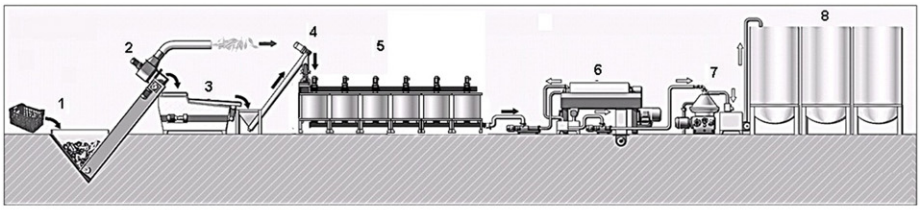

1

OLIVE DELIVERING
Once harvested from the trees, the olives must be processed as quickly as possible. They should normally be delivered to the mill immediately after picking, in order to keep down oxidation and acidity.

2

DEFOGLIATOR
The olives are therefore normally prepared for crushing by running them through a defoliator, where a powerful air flow begins the cleaning process by removing twigs, leaves, dirt, etc.

3

OLIVE WASHING MACHINE
The washer uses water to remove any remaining earth, stones and other debris from the olives. The washing water is recycled after decanting, and clean water is constantly mixed.

4

CRUSHING AND DEPITTING
Once cleaned, the olives must be crushed in order to make the olive paste. Crushing is the first stage in the VOO extraction process.

5

MALAXATION
The malaxing process determines the balance between the quality and the quantity of the oil extracted. This is done by varying a lot of parameters such as time, temperature and atmosphere in contact with olive paste. Usually the malaxers are installed in parallel, connected to a feed pipe with automatic valves.

6

CENTRIFUGATION
After malaxing, the olive paste is normally passed to a centrifuge which separates the oil and olive juice from the "pomace".

7

CLARIFICATION
The last main stage of the olive oil production process is the final clarification, in which a centrifuge separates the oil from any remaining water and olive residue.

8

STORAGE
After giving the most care and attention to the extraction process it is important to preserve the integrity of the product in the final stage, preventing temperature fluctuations and ensuring the retention of all the quality of the oil after it has been extracted.

Fig. 1. Processes and machines composing an olive oil processing line: 1—Delivery system; 2—Leaf removal system; 3—Washing machine; 4—Hammer mill; 5—Batch malaxers; 6—Decanter; 7—Separator; 8—Storage tanks; (photos courtesy of Alfa Laval SpA, GEA Westfalia Separator Group, Pieralisi & HakkıUsta).