Beyond the traditional virgin olive oil extraction systems: searching innovative and sustainable plant engineering solutions – An Ultrasound-Assisted extraction process.

The results of an experimentation conducted during the last harvesting season in collaboration with Alfa Laval, Weal srl and Olio Aloia.

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Ultrasound Olive Oil Extraction

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The aim of virgin olive oil elaboration process is to obtain the highest recovery of the best quality oil from the fruits. The aim of the researchers is to understand the key elements that allow to modulate the complex series of physical, physico-chemical, chemical and biochemical transformations in order to develop innovative and sustainable plant solutions able to increase simultaneously both yield and quality of product. Currently the systems for mechanically extracting virgin oils from olives are basically of two types: discontinuous-type systems (obsolete and dying out) and continuous-type systems. Systems defined as “continuous-type” are generally comprised of a mechanical crusher, a malaxer and a horizontal-axis centrifugal separator (decanter). The “continuous” appellation refers to the fact that two (mechanical crusher and decanter) out of the three machines making up the system operate continuously; the malaxer, which actually is a machine working in batches, is located between these two continuous apparatuses. Malaxation consists in a low and continuous kneading of olive paste (20-30 rpm for 30-45 min), needful to help the small droplets of the oil formed during the milling to merge into large drops (coalescence phenomena) that can be easily separated through mechanical systems. However, actually the malaxation represents the bottleneck of the continuous extraction process.

One industrial challenge of virgin olive oil plant manufacturing sector is to design and produce advanced machines in order to transform the discontinuous malaxing step in a continuous phase and improve the working capacity of the industrial plants. Ultrasound is an emerging technology that has already found application in the food industry. Yet, industrial application in the virgin olive oil sector has been scarcely investigated. In order to guarantee adequate virgin olive oil yields, reducing the process time and improving the process efficiency, the ultrasound has been applied because of their mechanical and thermal effects. Recently, Clodoveo in 2013 studied the employment of ultrasounds at the pilot plant scale for virgin olive oil elaboration process. Effectively, their mechanical actions were able to disrupt the

fruit cell walls that remained unbroken after crushing, releasing another fraction of oil and increasing virgin olive oil yields, while their thermal effects, faster than mechanisms of thermal conduction and thermal convection, reduced significantly the duration of malaxation, representing a first step toward a continuous process. Working toward the development of an innovative ultrasound equipment for the extraction of virgin olive oil, Clodoveo suggested to combine an ultrasound probe with a double-pipe heat exchanger.

The main idea was to realize a more efficient heat exchange before pumping the olive paste inside the malaxers, resolving another weakness of the current equipment: the low overall heat transfer coefficient due to the disadvantageous ratio (r) (r = S/V) between the small malaxer surface area (S) and large volume (V) of olive paste. In fact, in this way, a cheaper and more constructive simplification of the current malaxing machine can be realize, excluding the jacket for heating the olive paste and providing to a thermal insulating the tank. Starting from these previous evidences and hypothesis, an ultrasound system was developed and applied in an industrial-scale olive oil extraction plant to preliminarily analyze the installation and determine any advantages to improving the process continuity. A continuous process presents potential advantages such as minor operating costs, minor capacity limitations, faster return on investments, lower cost of production, reduced energy demands, reduced work-in-progress, faster and easier cleaning, real-time quality control and significantly reduced footprint facility. An optimization of olive mill energy usage is fundamental to meet the challenges of the virgin olive oil global market. Ultrasounds results a more sustainable technology than the conventional heat exchange. The sono-exchanger, which is engineering designed and prototyped to be industrially implemented, was evaluated in terms of time consuming to maintain acceptable yields of oils. Special attention was given to the nutritional aspects of the virgin olive oil processed by the innovative emerging technology by evaluating the antioxidant capacity of the product. Comparing the oils obtained with the employment of the innovative and the traditional systems, all samples,

sonicated or not, showed very low values of acidity, peroxide value, K232 and K270 so that they were defined as belonging to the commercial class of “extra virgin” olive oils. Considering these chemical parameters, no significant differences were found attributable to the ultrasonic treatment. The observed increments of tocopherols, carotenoids, and chlorophylls may be ascribed to the effect of ultrasounds that caused the phenomenon of acoustic cavitation. Acoustic cavitation has a strong impact on the solid surface and can disrupt biological cell walls. The mechanical effect of ultrasounds promotes the release of soluble compounds from the plant tissues by disrupting cell walls and improves mass transfer also in the olive tissues. A bright green colour of the oil results from the sonication of whole olives. As a large proportion of chlorophylls is contained in the epicarp, or in the skin, sonication seems to be an efficient method to break up the epicarp to release more pigments. Chlorophylls are essential both because they provide an aesthetic appearance of the product and they work as an antioxidant when the oil are stored in the dark. Considering the total polyphenols content, no significant differences were found attributable to the ultrasonic treatment, so no damage is attributable to the use of innovative technology. The Ultrasound treatment applied to olive paste before malaxation can increase the process efficiency by reducing the malaxation step. Further, this strategy makes it possible to reduce the number of kneaders, thus reducing the plant costs. The resulting virgin olive oil after the ultrasound treatment presents a more harmonic taste and an appealing and desirable color.

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