Conversion into food ingredients and solid biofuel from olive pomace biomass in centre inner region of Portugal

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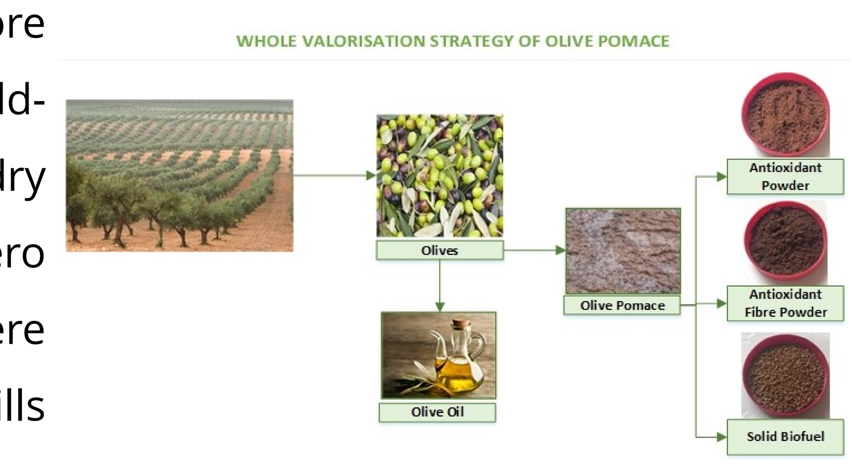
Introduction

The consumption of olive oil has been increasing due to its health benefits. As a result, the olive oil industry is turning one of the larger agro-food business sectors in Europe (≈ 80% of olive oil world's output), but also one of the greatest generator of biomass [1]. The most significant biomass is olive pomace (OP) [2]. OP is lignocellulosic biomass with a high amount of water (50-70%), dietary fibre [3], carbohydrates [4], phenolic compounds [5] and energy source.

The integration of energy dimension with high-value pathways in the same process could be an opportunity to solve the economic and environmental problem of olive pomace biomass.

Objectives

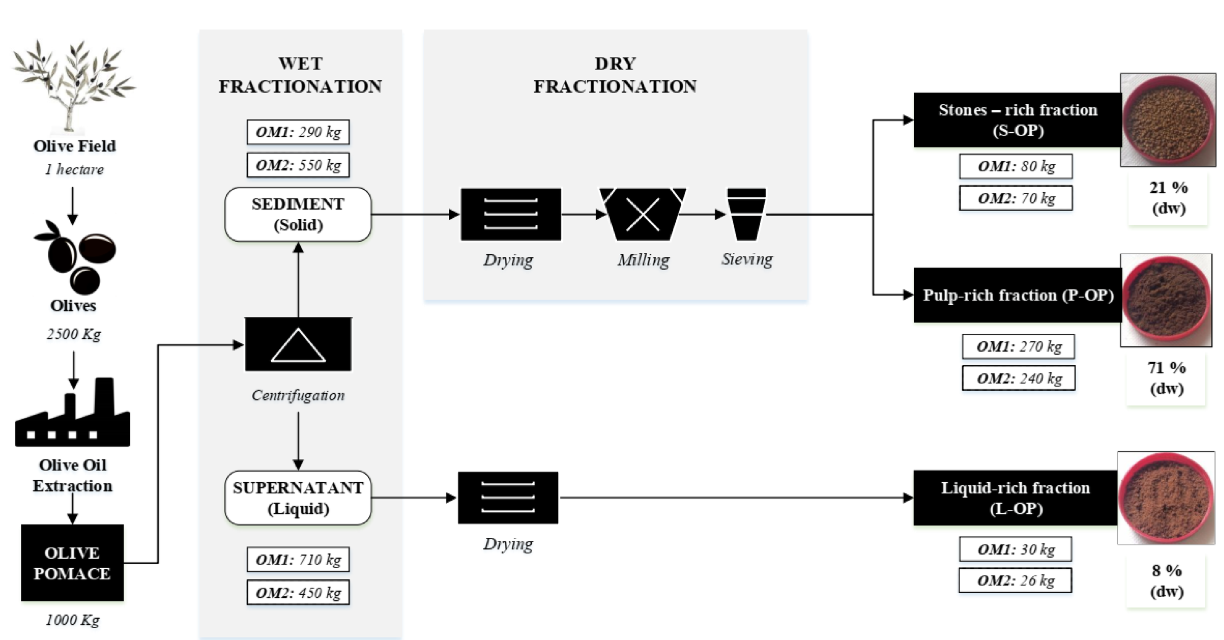
The present work aims to describe and validate an integrated approach to explore OP biomass as a source of different add-value products using wet and dry fractionation processes to achieve the "zero waste goal". As the case of the study were explored two samples from two olive mills (OM1 and OM2) from the centre inner region of Portugal.



Methods

1) Wet and dry fractionation process

The fractionation processes allowed to obtain a liquid-rich (L-OP), a pulp-rich (P-OP) and stone rich fractions (S-OP).



2) Nutritional profile and chemical composition (sugars, fibre, and polyphenols)

Moisture was determined gravimetrically (AOAC 934.06, 1990). Crude ash content was estimated by incineration (AOAC 945.05, 1990). Crude protein content was determined using the Kjeldahl method. Lipid content was obtained following Soxhlet extraction (AOAC 920.39, 1990). Crude fibre content was estimated by Weende method (AOAC 962.09, 1990). The available carbohydrate was estimated by difference.

Free sugar profiles were determined by HPLC coupled to a refraction index detector using an Aminex 37-H column and 35 mM H_2SO_4 as mobile phase at a flow rate of 0.5 mL/min. The results were expressed in g/ 100 g DW.

Extraction procedures of free (FPC) and bound phenolic compounds (BPC), followed the method described by Xie *et al.* (2015) with some modifications [7]. Total Phenolic Compounds (TPC) were analysed using the methods Folin-Ciocalteau [mg gallic acid equivalents (GAE)/100 g dry weight (DW)].

Identification of the main FP and BP phenolic compounds by HPLC method [8] was performed by comparison of retention times, spectra and peak areas at maximum absorption wavelength.

3) Determination of calorific power (Higher Heating Value)

The higher heating values (HHVs) of C-OP, S-OP and P-OP samples were measured by an automatic adiabatic bomb calorimeter (Parr calorimeter Type 6200). Measurements were made in duplicate (1 g) according to EN 14918.

Results and Discussion

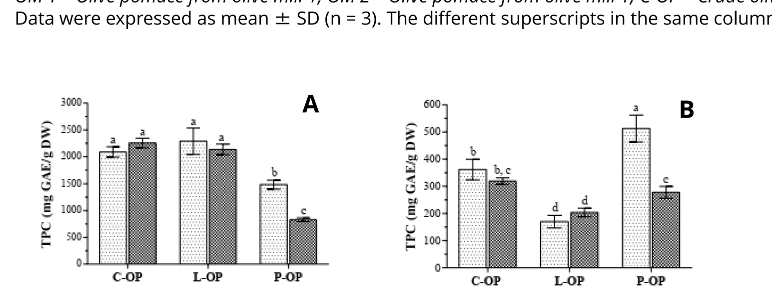
The nutritional profile and chemical composition (sugars, fibre and polyphenols) of olive pomace biomass and its edible fractions (L-OP and P-OP) were assessed.

An antioxidant-rich powder containing high amounts of hydroxytyrosol was achieved (514-626 mg/ 100 g DW) from L-OP, as well as an antioxidant fibre-rich powder obtained from the P-OP (55-54 g fibre/ 100 g DW).

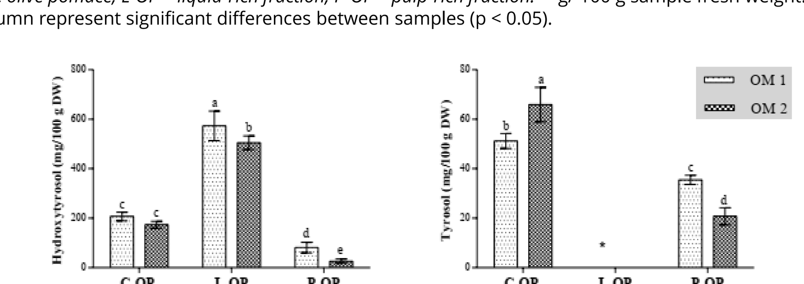
Chemical composition of C-OP) and edible olive pomace fractions (l-OP and P-OP) produced after the wet and dry fractionation process (g/ 100 g DW).

Chemical Components	Composition (g/ 100 g DW)					
	C - OP		L-OP		P-OP	
	OM 1	OM 2	OM 1	OM 2	OM 1	OM 2
Crude Fibre	35.90 ± 1.32 [b]	31.94 ± 1.44 [b]	0.13 ± 0.10 [c]	0.09 ± 0.01 [c]	54.54 ± 2.63 [a]	54.08 ± 2.06 [a]
Moisture*[1]	68.34 ± 0.43 [c]	78.43 ± 3.01 [b]	88.64 ± 0.36 [a]	95.29 ± 0.81 [a]	62.07 ± 0.08 [c]	68.18 ± 1.86 [c]
Ash	4.48 ± 0.09 [c]	4.93 ± 0.09 [d]	10.74 ± 0.21 [b]	11.27 ± 0.18 [a]	3.11 ± 0.19 [e]	1.97 ± 0.03 [f]
Protein	8.75 ± 0.13 [a]	8.82 ± 0.15 [a]	3.80 ± 0.24 [d]	4.41 ± 0.12 [c]	7.98 ± 0.18 [b]	8.71 ± 0.12 [a]
Fat	15.61 ± 1.37 [b]	20.04 ± 0.58 [a]	2.68 ± 0.29 [d]	5.56 ± 0.50 [c]	14.99 ± 0.41 [b]	21.34 ± 0.94 [a]
Carbohydrates	34.27 ± 2.48 [b]	33.29 ± 1.35 [b]	79.83 ± 0.65[a]	76.21 ± 0.79 [a]	19.09 ± 2.88 [c]	12.91 ± 2.02 [d]
Soluble Sugars						
Glucose	6.85 ± 1.42 [b]	6.31 ± 0.61 [b, c]	19.75 ± 2.00[c]	20.37 ± 1.74 [c]	4.00 ± 0.90 [b, c]	2.67 ± 0.61 [c]
Mannitol	7.16 ± 1.40 [c, d]	10.55 ± 1.66 [c]	21.10 ± 2.55 [c]	32.37 ± 2.65 [b]	4.81 ± 1.61 [c]	4.08 ± 0.88 [d]

OM 1 – Olive pomace from olive mill 1; OM 2 – Olive pomace from olive mill 1; C-OP – Crude olive pomace; L-OP – liquid-rich fraction; P-OP – pulp-rich fraction. *[1] g/ 100 g sample fresh weight. Data were expressed as mean ± SD (n = 3). The different superscripts in the same column represent significant differences between samples ($p < 0.05$).



Content of free(A) and bounds phenolic compounds(B) from C-OP, L-OP and P-OP (mg gallic acid equivalent/100 g DW).



Hydroxytyrosol and tyrosol composition (mg/100 g DW) in C-OP, L-OP and P-OP from olive pomace.

The higher heating value from non-edible fraction (S-OP) was estimated.

The use of S-OP instead of crude OP biomass as solid biofuel was a suitable choice, due to its low moisture (6% DW), uniform size, high density without compromising its higher heating value (18.94 and 18.65 MJ/kg DW).

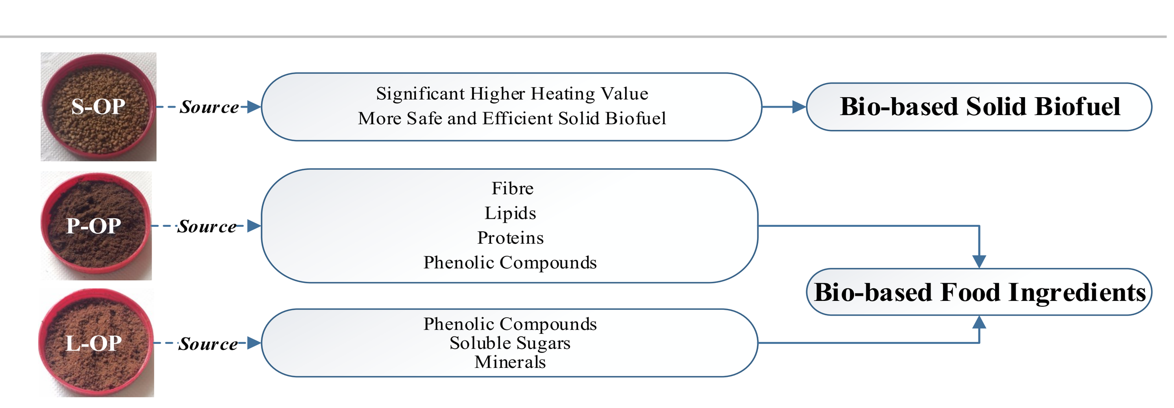
Higher Heating value (HHV) of crude olive pomace (C-OP) and olive pomace fractions produced after the wet and dry fractionation process (MJ/Kg DW).

High calorific value (MJ/Kg dry weight)							
C-OP		P + S-OP		P-OP		S-OP	
OM 1	OM 2	OM 1	OM 2	OM 1	OM 2	OM 1	OM 2
20.57 ± 0.03 [c, d]	21.67 ± 0.20 [b]	20.21 ± 0.05 [d]	20.86 ± 0.11 [c]	21.52 ± 0.12 [b]	22.21 ± 0.01 [a]	18.94 ± 0.00 [d]	18.65 ± 0.00 [d]

OM 1 – Olive pomace from olive mill 1; OM 2 – Olive pomace from olive mill 1; C-OP – Crude olive pomace; L-OP – liquid-rich fraction; P-OP – pulp-rich fraction. *[1] g/ 100 g sample fresh weight. Data were expressed as mean ± SD (n = 3). The different superscripts in the same column represent significant differences between samples ($p < 0.05$).

Conclusions

The chemical characterization of L-OP and P-OP revealed that fractionation approach seems to be a very promising eco-friendly methodology to obtain new food ingredients: antioxidant powder and antioxidant fibre powder. As well, the higher heating value estimation of S-OP supports the possibility of integrating in the same process the production of a solid biofuel for energy purposes, based on a cascade use of biomass principle. The fractionation approach developed allowed not only to achieve the "zero waste goal", but also add economic value and to reduce the environmental impact of the olive oil sector.



References: **(1)** G. Banias, C. Achillas, C. Vlachokostas, N. Moussiopoulos and M. Stefanou, *J. Sci. Food Agric.*, 2017, 97, 1686–1697. **(2)** S. Dermeche, M. Nadour, C. Larroche, F. Moulti-Mati and P. Michaud, *Process Biochem.*, 2013, 48, 1532–1552. **(3)** G. Rodríguez-Gutiérrez, F. Rubio-Senent, A. Lama-Muñoz, A. García and J. FernándezBolaños, *J. Agric. Food Chem.*, 2014, 62, 8973 8981. **(4)** A. Lama-Muñoz, G. Rodríguez-Gutiérrez, F. RubioSenent and J. Fernández-Bolaños, *Food Hydrocoll.*, 2012, 28, 92–104. **(5)** N. C. Icyer, O. S. Toker, S. Karasu, F. Tornuk, F. Bozkurt, M. Arici and O. Sagdic, *LWT - Food Sci. Technol.*, 2016, 70, 24–32. **(6)** J. Mata Sánchez, J. A. Pérez Jiménez, M. J. Díaz Villanueva, A. Serrano, N. Núñez and J. López Giménez, *Renew. Energy*, 2015, 78, 566–572. **(7)** Xie P-J, Huang L-X, Zhang C-H, Zhang Y-L. Phenolic compositions, and antioxidant performance of olive leaf and fruit (Olea europaea L.) extracts and their structure– activity relationships. J Funct Foods. **2015**; 16:460–71. **(8)** C. M. Oliveira, A. S. Barros, A. C. Silva Ferreira and A. M. S. Silva, Food Res. Int., 2015, 75, 337–347.

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