Effect of storage and drying on the composition of two-phase pomace

A. Christofi, V. Stoumpou, E.M. Barampouti, S. Mai, K. Moustakas, M. Loizidou

National Technical University of Athens, School of Chemical Engineering, Unit of Environmental Science Technology, 9 Heroon Polytechniou Str., Zographou Campus, GR-15780 Athens, Greece

(E-mail: christofi_andreas@outlook.com; valia.stoumpou@gmail.com; belli@central.ntua.gr; mai@central.ntua.gr; konmoust@central.ntua.gr; mloiz@chemeng.ntua.gr)

Introduction

The global production of olive oil in 2019-2020 reached 3.2 million tons. The European Union occupied 60% of the global production corresponding to 1.9 million tons. This production is mainly concentrated in Spain (58.4%), Italy (19.0%) and Greece (14.3%). The main production processes are three-phase and two-phase olive mills. The latter are gaining ground due to the recent legislation. Two-phase olive mills have as their product olive oil and as by-products the two-phase pomace as well as a small amount of wastewater which derives from the water used in the last stage of the clarification process. The two-phase pomace is a semi-solid waste that consists of large amounts of moisture (50-75%), olive kernel, pieces of olive peel and pulp as well as residues from leaves and pruning. The waste of the two-phase pomace represents more than 80% of the raw material processed. Uncontrolled discharge of waste into the soil causes strong phytotoxic effects, increases soil hydrophobicity, reduces water retention and filtration rate, as well as affects acidity, salinity, nitrogen uptake, microbial activity, leaching lipid concentration, and production of organic acids and phenols. A common valorisation pathway of the two-phase pomace is the extraction of pomace oil in pomace oil plants. A typical plant includes a drying step in a rotary drum dryer in order to reduce the moisture of pomace to 8% as well as an oil extraction step with hexane. The main environmental issue that these plants face is the emissions to the atmosphere that become a serious nuisance to the local communities. In this context, the current paper focuses on the study of the effect of storage and drying on the composition of two-phase pomace.

Materials and Methods

Various samples were collected from a two-phase olive mill and a pomace oil plant in Messinia, Greece, and transferred to the Unit of Environmental Science and Technology (UEST), School of Chemical Engineering, National Technical University of Athens. Fig.1 illustrates the sampling points in the value chain of pomace oil, from the production of pomace in the olive mill until the production of dried pomace.

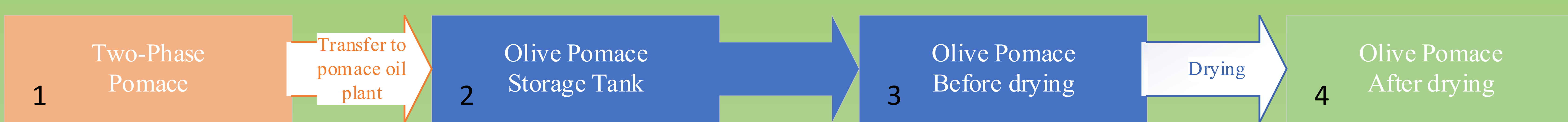

Figure 1: Simplified flow diagram of the sampling points in the value chain of pomace oil

Results & Discussion

Tables 1 and 2 present the composition of the solid and liquid phases of the samples, where several differences were observed among them. Cellulose and hemicellulose showed a major decrease in concentration in the sample collected after the drying stage whilst the concentrations of these compounds remained relatively constant at the stages prior to drying. Lignin seemed to have negligible alteration during all stages.

Table 1: Chemical composition of the solid phase

	Two-phase pomace	Olive pomace storage tank	Olive pomace before drying	Olive pomace after drying
Moisture, %	60.36	68.34	45.07	5.24
Total Solids, %	39.64	31.66	54.93	94.76
WSS, % d.b	15.89	14.66	12.61	20.23
Cellulose, % d.b	8.93	8.96	9.14	6.67
Hemicellulose,% d.b	27.50	29.75	27.09	20.78
AIL, % d.b	42.42	47.64	47.15	46.73
ASL, % d.b	0.94	0.90	0.99	1.56
Oil, % d.b	13.71	14.49	12.17	14.00

Table 2: Chemical composition in the liquid phase

	Two-phase pomace	Olive pomace storage tank
Conductivity, μS/cm	13680	16200
TOC, mg/L	46115	34815
TN, mg/L	96.3	91.55
VFA, mg/L	11200	14575
Phenols, mg/L	797.5	595
Xylose, g/L	3	0.05
Glucose g/L	5.05	1.5
Glycerol, g/L	1.15	-
Ethanol, g/L	9.55	12.15

Lignin seemed to have negligible alteration during all stages. Regarding the concentrations in the liquid phase, a drop of glucose and a rise of ethanol were observed between the two-phase pomace and the sample of olive pomace storage tank, revealing the effect of storage on these soluble components and indicating that a fermentation process took place. From the XRD analysis (Fig.2), the crystallinity indices (CI) of the samples were estimated.

These results revealed that the two-phase pomace presented higher CI (CI=21.20) compared to olive pomace before (CI=16.34) and after (CI=19.70) drying. Furthermore, based on these results, it can be deduced that cellulose was converted into a more amorphous structure.

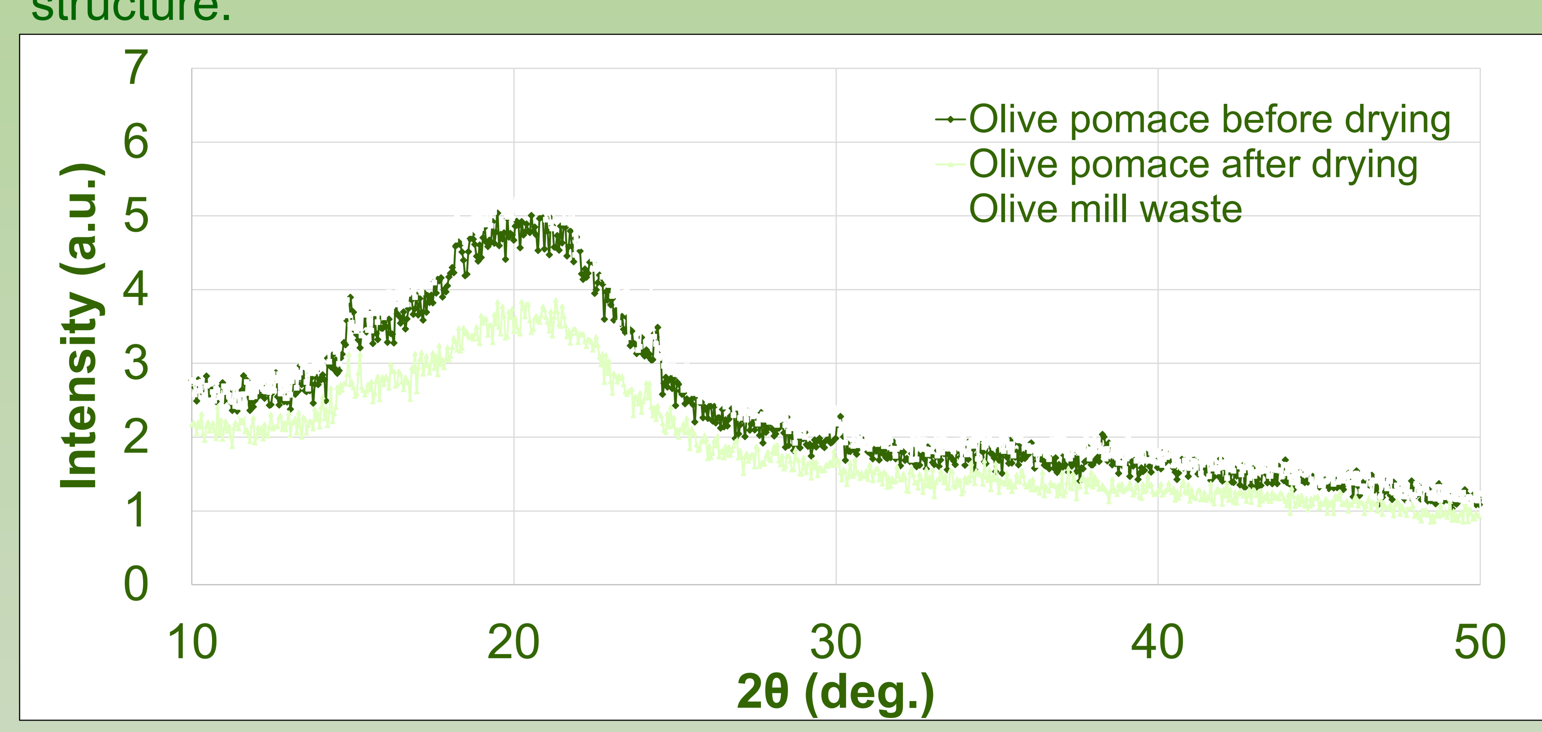

Figure 2: XRD analysis of the examined samples

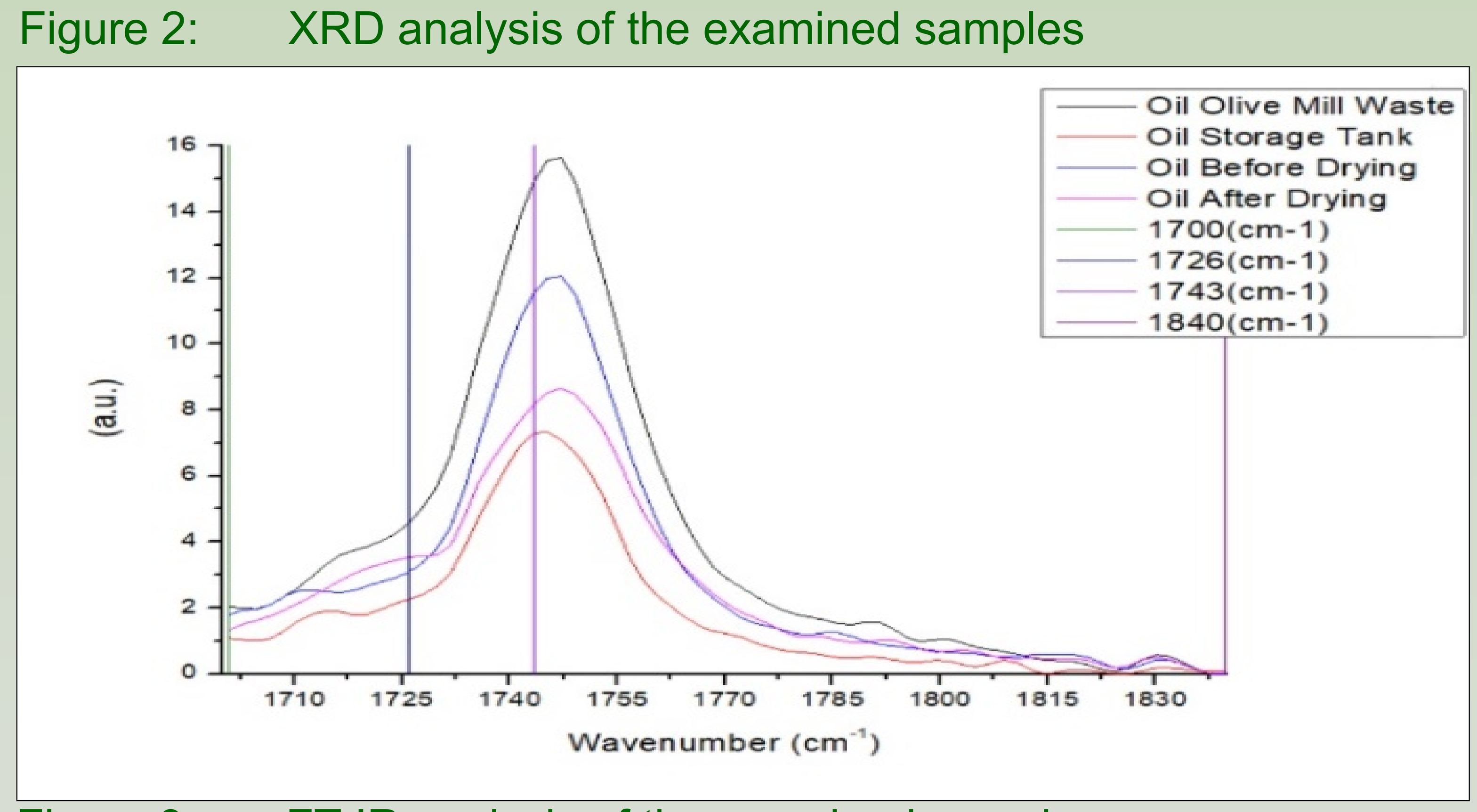

Figure 3: FT-IR analysis of the examined samples

From the FT-IR analysis, it was revealed that ketones and aldehydes are produced from oil oxidation due to the presence of oxygen and UV radiation at the storage conditions. Moreover, a greater ratio of areas is observed after the drying stage (0.30) in comparison with the sample collected before drying (0.27), which may be attributed to the production of ketones and aldehydes in the drying phase due to thermal decomposition.

Conclusions

Differences in compositions have been observed in all samples of olive pomace. More specifically, the drying process seemed to have a significant effect on the decomposition of carbohydrates such as hemicellulose and cellulose. Storage conditions favoured oil oxidation and affected the oil composition. Last, the production of ketones and aldehydes is favoured in the drying phase due to thermal decomposition.

Acknowledgments

The authors gratefully acknowledge the financial support of the Regional Development Fund of the Region of Peloponnese.