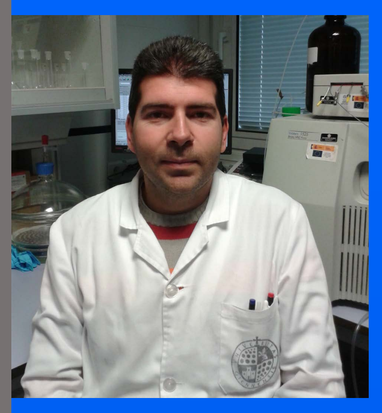
Olive leaves as a source of lignin, antioxidants and bioethanol. A technical evaluation

J.M. Romero-García[1], J.C. Solarte-Toro[2], E. Ruiz[1], I. Romero[1], C.A. Cardona-Alzate[2], E. Castro[1]*

[1]Department of Chemical, Environmental and Materials Engineering; Center for Advanced Studies in Earth Science, Energy and Environment (CEATEMA). Universidad de Jaén. Campus Las Lagunillas s/n | 23071 - Jaén (Spain).

[2]Instituto de Biotecnología y Agroindustria, Departamento de Ingeniería Química, Universidad Nacional de Colombia, Manizales campus. Km 07 vía al Magdalena Manizales - Colombia..

**Presenting author email: jrgarcia@ujaen.es*



Introduction

Olive leaves (OL) are a lignocellulosic material generated in high amounts during the olive oil production. World production of olives exceeds 18 million tonnes and these are accompanied by 4-7 %w. of OL, which can represent 1 million tonnes of leaves. In Spain, the annually estimated amount of OL along these industries may exceed 3 hundred thousand tonnes, with the major production in Andalusia (87.8 % of total). OL are not used to produce any value-added product and they are disposed in landfills, occasionally is removed for animal feed. Nevertheless, OL have a great potential to be used as an antioxidants, lignin and ethanol source through the implementation of chemical and biochemical processes. In accordance with the above,

The aim of this work is to evaluate from the techno-economic point of view, the production of lignin, antioxidants and bioethanol using olive leaves as raw material through a two-stage organosolv pretreatment and a simultaneous saccharification and fermentation process taking into account experimental yields obtained at laboratory scale.

Figure 1: Block diagram of the bioethanol production process using olive tree biomass as raw material.

Methodology

1. Chemical characterization of the olive leaves using the NREL methods for lignocellulosic biomass.
2. Conceptual design of the biorefinery using the hierarchy, sequencing and integration concepts.
3. Simulation of the biorefinery to obtain the mass and energy balances using the simulation software Aspen Plus v.9.0.
4. Economic assessment using the simulation software Aspen Process Economic Analyzer v.9.0. The tax rate, interest rate, operator and supervisor costs were considered in the Spain context.
5. Environmental assessment of the proposed process using the environmental indicators according to the GREENSCOPE methodology endorsed by the EPA.
6. Sensivity analysis of the antioxidants price aiming to evaluate the prefeasibility of the biorefinery.

Results

Table 1. Mass yields and product purity obtained from the proposed biorefinery.

Product	Mass yields (kg/kg OL)	Product purity (% w/w)
Ethanol	0.03	99.50
Lignin	0.12	65.00
Antioxidants	0.38	20.00

Economic indicators

Internal rate of return: 15.22%
Profitability index: 1.16
Payback period: 7.27 years
NPV: 33.79 M.USD

Environmental indicators.

Calculated indicators are slightly higher compared with conventional processes like bioethanol, biodiesel and biogas production.

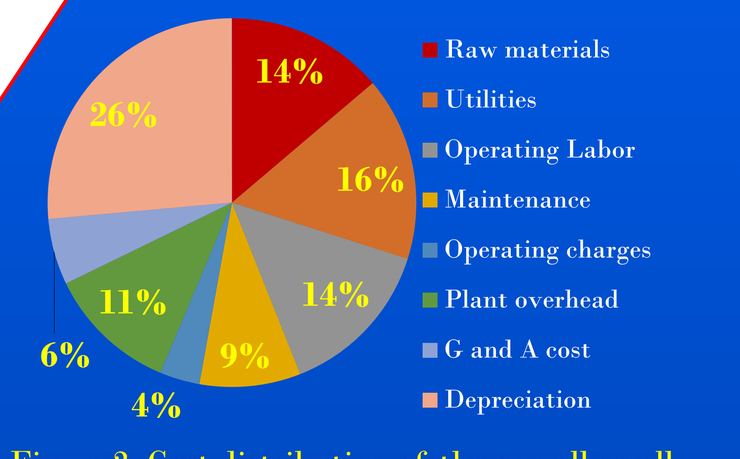


Figure 2: Cost distribution of the overall small-scale biorefinery.

Table 2. Environmental indicators calculated for the biorefinery.

Indicator	Indicator	Units
Specific liquid waste	18.31	kg waste water/kg
Specific solid waste	0.76	kg gypsum/kg
Global warming potential	0.28	$kgCO_2/kg$
Hazard materials input	0.54	kg hazardous material/kg

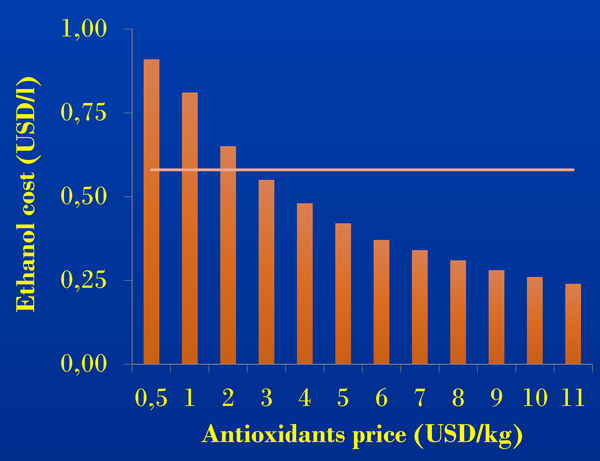
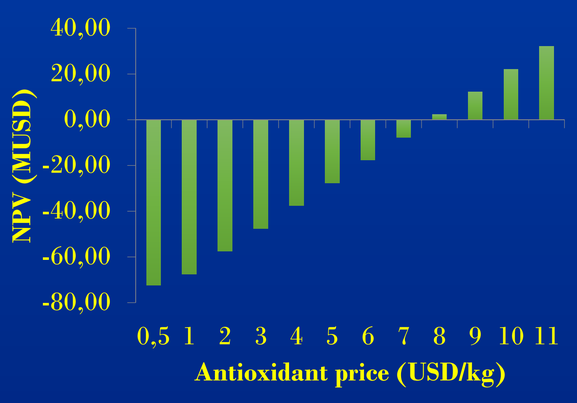


Figure 3. Influence of the antioxidants selling price in bioethanol cost.

Figure 2. Influence of the antioxidants selling price in the NPV of the biorefinery.



Conclusions

As a conclusion from this work, the organosolv process has great advantages from the technical point of view, because it allows to recover the main three factions of the lignocellulosic matrix of the olive leaves. In addition, at low operating conditions, the antioxidants obtainment is possible. However, the economics of this process must be analyzed more deeply with the end to elucidate if the organosolv technology is economically feasible. This work also shows that the production of high value-added products such as antioxidants can slightly support the production of bulk chemicals such as bioethanol. Finally, it was possible to determine that the olive leaves are a high potential feedstock that can be used to increase the value of the olive production chain using different conversion technologies that not necessarily include those evaluated in this

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