Life Olea Regenera

(LIFE17 ENV/ES/000189)

Valorization of bio-waste resulting from the olive oil extraction process

(Valorización de los bio-residuos procedentes del proceso de extracción del aceite de oliva)

LAYMAN'S REPORT

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Olea Regenera

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1. PROJECT SUMMARY

Title:
"Valorization of bio-waste resulting from the olive oil extraction process"

Coordinating Beneficiary:
FERTILIZANTES Y UNTRIENTES ECOLÓGICOS, S.L. (FYNECO)

Associated Beneficiaries:
ORUJO FRÍO, S.L. (OF)
SOLEX IBERICA DE SECADOS GRANULARES, S.L. (SOLEX)
CEBAS (CSIC)
OLIVAIS DO SUL, S.A. (ODS)

Project duration: 01/09/2018- 31/12/2022
Project budget: 1.824.730 €
Project eligible costs: 1.658.992 €
EU Contribution: 995.395 €

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Project Website: https://lifeolearegenera.com/

2. INTRODUCTION

The European Union is the world's largest olive oil producer, accounting for the 65 to 75% of the world's olive oil production (3.22 million tonnes in 2019/2020 season), and has plantations and processing facilities in 8 member states with a total production value of over EUR 7 billion, which highlights the strategic economic importance of the olive oil sector in the EU and its influential position in the international arena.

However, the olive oil extraction process which is currently used in Europe is not sustainable: only about 22% of the mass of the olive can be extracted as olive oil and the rest is discharged in a mass called *alperujo*, a mixture of vegetation water, olive skin, olive pulp and crushed olive pits. This residue is transported long-distance by road (usually hundreds of kilometres) to *orujeras* (secondary extraction factories where the olive mill waste is treated to obtain biomass and low-quality oil), so that, after passing through dryers where its humidity is reduced from 80% to 10%, pomace oil is extracted by chemical processes.

The process is not environmentally acceptable either because, during the *alperujo* drying process with forced evaporation, suspended particles and other compounds of degradation are emitted by the chimneys of *orujeras*, well above the thresholds allowed by the current regulations, even though filtering solutions are used. In fact, air pollution is so severe around *orujera*s that most of those located nearby urban places have been closed.

If a solution is not quickly sought to the unsustainability of these emissions, *orujera*s will not be able to process the more than 12 billion tonnes of *alperujo* that are generated each year in Europe as a result of olive oil production, which may collapse the production process and threaten this economic activity.

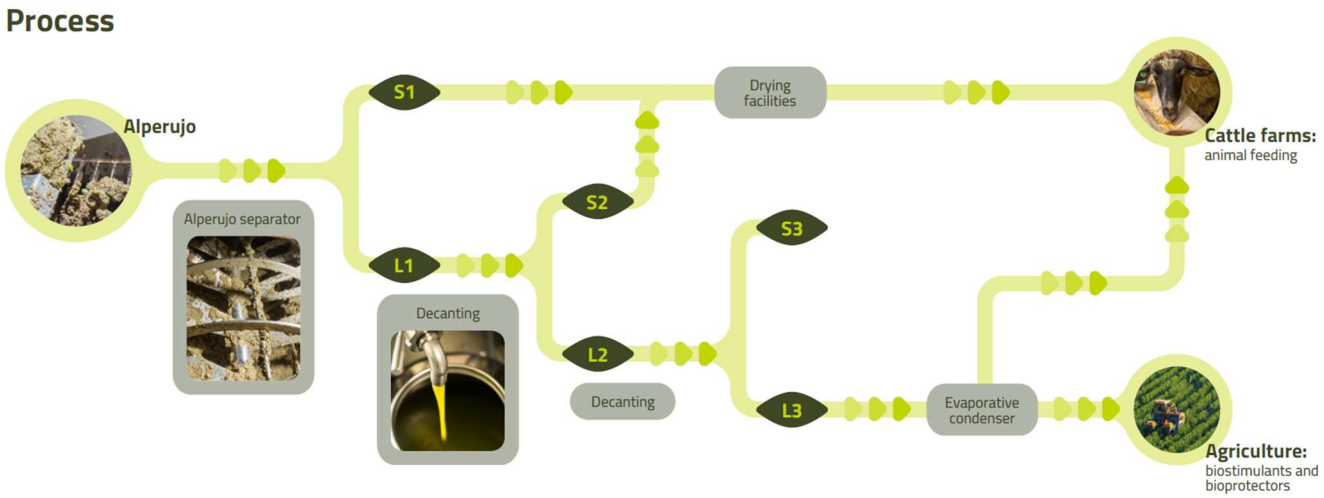
The LIFE OLEA REGENERA project aims to demonstrate a technical solution for the management of alperujo, eliminating the amount of waste to be sent to *orujera*s and transforming this pollutant waste into valuable by-products.

3. PROJECT SCOPE AND OBJECTIVES

The main objective of the LIFE OLEA REGENERA project has been to demonstrate the valorisation of the bio-waste resulting from the olive oil extraction process, the alperujo, by transforming it into new by-products that can be used as functional animal feed or biostimulants for crops.

During the preparation action (Action A1), OF developed the design and engineering of the equipment needed for separating the alperujo that is currently installed in the olive mill Casa Grande, in Jaén (Spain). This final design has experienced some variations to what was initially planned in the project proposal in order to guarantee the production of stable and potentially commercial by-products.

After processing the alperujo in this equipment, two by-products are obtained. A solid S1+S2 that was used in the preparation of animal feed and a liquid L3 that was used to make different formulations of biostimulants for agriculture and also for animal feed.



Final alperujo separation process

FYNECO developed 6 biostimulant formulations with the L3 obtained with the new alperujo separation process.
As the polyphenols and salts contained in the concentrated L3 could have been toxic to plants, it was necessary to evaluate the maximum HT concentration that the plants could admit as well as the perseverance of the phenols and salts in the soil before defining the final formulations. For this, CEBAS carried out some additional tests that were necessary to conclude this Action. With the results of these trials, FYNECO readjusted the initial formulations that were finally tested in plants in action B2.

During the project, 12.495 tons of alperujo have been processed, obtaining 3.123 tons of solid byproduct (S1+S2), 875 tons of liquid byproduct (L3) and 8.497 tons of water.

On the other hand, the by-products S1+S2 and L3 obtained from the alperujo began to be analysed during the 2018/2019 olive campaign. In particular, during the first olive campaign, the best method to measure the HT concentration in L3 without damaging its properties was analysed, and during the 2019/2020 campaign, different methods to concentrate L3 also without damaging the rest of its components were analysed.

During the 2020/2021 and the 2021/2022 campaigns, the stability of the by-products over time was studied. The result of this action has been the characterisation of the by-products and the elaboration of their technical data sheets, which are necessary for the commercialization of the by-products.

As for the validation of the new commercial products obtained from byproducts (Action B2), after the characterisation of the by-products conducted in Action B1, preliminary tests were held, where animals were given feed formulated with L3 and S1+S2 to check that they ate it and that it had no adverse effect on them.

As a result of these trials, instead of focusing the studies on ruminants and monogastric as initially foreseen in the proposal, it was decided to focus the studies on the Iberian pig, as this will allow OF and SOLEX to sell the by-products at a higher price.

On the other hand CEBAS y FYNECO, in November 2020 the tests of biostimulant formulations from the liquid fraction of the alperujo began in different commercial crops (Olive trees, citrus fruits, lettuce, tomato, melon and grapes) and the formulations developed have had a very positive impact on crop. The quality of the by-products has also been validated by OF as animal feed s. This action has been a great success and the results have been better than expected in the proposal.

Regarding the transfer and replication activities (Action B3), the replication and transfer strategy has been produced. The validation of biostimulant products in Portuguese olive trees took place in 2021, where seven trials were conducted, one for each product and one as a control. The results obtained in Portugal assay were very positive. The application of the different formulas influenced in yield, quality of the harvest and in the oil obtained. Finally, the alperujo separator (the first phase of the alperujo separation process able to separate the alperujo into S1 and L1) has been installed in the ODS facilities.

As for the market replication activities (Action B4), both FYNECO and OF have carried out a business plan and a market study to commercialise the alperujo separation process and the byproducts obtained. In addition, FYNECO, OF and SOLEX have carried out the necessary actions to guarantee the protection of Intellectual Property Rights of all the developments and products created in the project, and have paved the way for their commercialisation by 2023. In fact, the commercialisation of S1+S2 has started earlier than expected and SOLEX already has revenues generated by the project.

Regarding the project results monitoring (Action C1), the LIFE Key environmental and economic indicators have been monitored and assessed by all project partners, while the communication indicators have been monitored by FYNECO. Finally, The LCA assessment has been done, which concluded that the products obtained by the LIFE OLEA REGENERA project represent high quality solutions with low environmental impact, taking advantage of the waste from oil milling, which accounted for approximately 80% of the product obtained from olive milling, to convert it into a source of new beneficial products with high added value. Investments in resources and efforts in innovation and development such as those of this project bring benefits both for the oil industry, encouraging the continuous adaptation of a sector that has always been defined as traditional, and for the environment and society as a whole.

On the other hand, regarding the dissemination planning and execution (Action D1), the LIFE OLEA REGERNA communication plan has been done, containing the project image, templates for the project's materials, the dissemination and communication objectives, target groups, schedule communication and dissemination activities and expected results.

The project website https://lifeolearegenera.com/en/ has also been created and is been regularly update. The noticeboards and the project leaflets have been designed and distributed. Six newsletters have been launched reporting on project activities. A preliminary stakeholders database was done at the beginning of the project. A Twitter account of the project (@OleaLife) has also been created. The project has attended to multiple events, such as the Expoliva 2019 and 2021. The project has also organised several field visits and has participated in different workshops and webinars, where the project results have been presented. The project has also done networking activities with 9 related projects, with whom synergies

have been identified and a collaboration has been initiated. Finally, the project has organised a final conference in Jaen, where relevant national and international stakeholders attended and discussed about the project and the current situation of the sector.

Finally, as for the project management (Action F1), the project Steering Committee has regularly met in order to monitor and assess the work plan and objectives, as well as rectifying all deviations occurred. On the other hand, despite the accumulated delay of several months in some project tasks, the consortium has drawn up a contingency plan and requested a 9-month extension which has made it possible to complete all the project's activities and achieve all project objectives.

4. PROJECT LOCATION

The activities developed in the project have been carried out in different locations.

OF developed the design and engineering of the equipment needed for separating the alperujo that is currently installed in the olive mill Casa Grande, in Jaén (Spain).

On the other hand, FYNECO and CEBAS carried out the tests of the different biostimulant formulations from the liquid fraction of the alperujo in crops. These trials were carried out in the Region of Murcia and Jaén.
Regarding the transfer and replication activities, the validation of biostimulant products in Portuguese olive trees took place (Monte Do Trigo), where seven trials were conducted, one for each product and one as a control.

The results obtained in the tests were very positive. The application of the different formulas influenced the yield, quality of the harvest and the oil obtained. Finally, at the ODS facilities the alperujo separator has been installed (the first stage of the alperujo separation process capable of separating the alperujo into solid and liquid phases).

5. EXPECTED RESULTS AND ENVIRONMENTAL BENEFITS

The project will have very positive impacts at environmental and economic levels, thanks to this project it is possible to value and introduce into the market a product that is currently treated as a waste. This will also contribute to minimise the serious environmental problem caused by the presence of harmful pollutants in the gases emitted in orujeras, with a high cost over human health and air quality.

With the new alperujo separation process, LIFE OLEA REGENARA **reduces up to 100% the olive oil extraction waste** that currently goes to orujeras. The system proposed produces a solid fraction which can be used as animal food, a liquid fraction which can be converted into biostimulant or supplement for animal feed, and water.

Additionally, the alperujo separation process installed in Vadolivo facilities allows:

- The reduction in 5000tn/year of the alperujo sent to orujeras, as the alperujo separation system has been designed to be installed in olive mills, reducing also the CO2 emissions derived from transport by road. This figure will be higher if replication activities are successful and more alperujo separation systems are installed in additional olive mills.
- The reduction in orujeras's emissions and energy consumption, as they treat less amount of alperujo.

Other project results are:

- Definition of protocols of production of the new solid fraction, with low production costs and high concentration of vegetable fat of excellent nutritional quality.
- Definition of protocols of production of the new liquid fraction, with low production costs and high concentration of hydroxytyrosol (polyphenol).
- Prototype and parametrization of the necessary equipment to achieve the by-products from alperujo.
- Technical and economic feasibility studies to install the alperujo separation process in other olive mills and replicate the process.
- Cost-benefit analysis, market study, business plan and exploitation plan of the proposed system and by-products.
- Socioeconomic and business benefits for the participating companies that aims to commercialise new products whose characteristics will make them unique in the global market.

6. EXPECTED LONGER TERM RESULTS

Once the viability of the alperujo separation process and the by-products have been assessed, and its positive impact on the environment has been proven, great interest in implementing this technology is expected in the olive industry. The profit that is expected to be achieved after the commercialization of the alperujo separation process and the by-products will create an obvious economic interest that will allow the project replication in the years beyond the project.

Thus, after 5 years of project implementation, it is expected to:

- Replication of the alperujo separation process in at least 3 olive mills.
- To process at least 259,200 tons of alperujo in those 3 olive mills.
- To reduce the air pollutant emissions of the processing of these 259,200 tons of alperujo in a 100%.
- To produce more than 29,000 tons of liquid byproduct that can be used as animal feed or as biostimulant
- To produce more than 90,000 tons of solid byproduct that can be used as animal feed..
- To reduce the CO2 emissions produced by the transport by road of alperujo to orujeras by 943 tons.

To generate more than EUR 9,000,000 of incomes thanks to the commercialization of the alperujo separation process and the by-products.

7. ANALYSIS OF BENEFITS

Environmental benefits

1. *Direct / quantitative environmental benefits:*

- 12.495 tons of alperujo have already been transformed into byproducts, preventing them from been dried and processed in an orujeras, which is a 250% more than what was foreseen in the proposal.
- 3.123 tons of S1+S2 have been produced to be tested as animal feed, which is a 253% more than what was foreseen in the proposal.
- 875 tons of L3 (before concentration) have been produced, a 199% more than foreseen, from which 4 tones have been transformed into biostimulants and 6 have been used as animal feed.
- The new alperujo separation process allows a 100% of the transformation of the waste into valuable byproducts, closing the cycle.
- The project has already covered the waste generated in 5.164 ha of olive growing land, a 250% more than foreseen.
- 45,5 tons of CO2 have been eliminated as a result of the processing of alperujo in the olive mill and avoiding its transport to an orujeras, a 250% than foreseen in the project proposal.

2. *Qualitative environmental benefits*

The LIFE OLEA REGENERA project has brought to market an innovative solution to eliminate the residue generated by the olive oil industry: the alperujo.

This project has also contributed to the European Green Deal Goal 8: **Releasing a zero-pollution ambition for a toxic free environment,** since the alperujo separation technology replaces the highly polluting dryers installed in orujeras with an environmentally **friendlier process**. In this case, orujeras will reduce their polluting emissions (mainly PM10) by 100%.

Economic benefits

On the one hand, the project is already having a economic impact in the number of jobs created:

	Unskilled employment	Qualified employement
FYNECO	1 operator	1 administrative
ORUJO FRÍO	1 operator	1 project director 1 administrative
CEBAS		2 technicians
SOLEX	1 operator	

On the other hand, the LIFE OLEA REGENERA project aimed to introduce into the market, a technological solution for the alperujo processing that will allow the olive industry to continue being a reference in Europe while eliminating the problem of polluting emissions. Additionally, the project has valued the byproducts obtained from the alperujo separation process.

The following products and processes are now ready to be commercialied and these are the expected income in 5 years:

Products for sale	Unit price	Number of clients expected in 5 years	Expected sales in 5 years	Expected income in 5 years
production process for the treatment of alperujo	3.000.000 €/unit	2 clients	2 unit (1 per customer)	6.000.000 €
Fibroliva	90-120 €/Tn	100 clients	30000 Tn (300 tn per customer)	3.000.000 €
L3 for animal feed	80-110 €/Tn	10 clients	1500 Tn (150 tn per customer)	150.000 €
L3 para biostimulants	150 €/Tn	1 client (FYNECO)	17.64 Tn	2.646 €
Formula 1	7 €/liter	15 clients	18.000 liters (1.200 liters per customer)	126.000 €
Formula 2	5 €/liter	15 clients	8.000 liters (530 liters per customer)	40.000 €
Formula 3	4 €/liter	5 clients	3.000 liters (600 liters per customer)	12.000 €
Formula 4	9 €/liter	15 clients	7.000 liters (460 liters per customer)	63.000 €
Formula 5	8 €/liter	5 clients	4.000 liters (800 liters per customer)	32.000 €
Formula 6	14 €/liter	5 clients	2.000 liters (400 liters per customer)	28.000 €
TOTAL		**127 clients**		**9.453.646 €**

Expected revenue breakdown

Social benefits

The project is in line with global policy initiatives as the United Nations' **12th Sustainable Development Goal (Ensure sustainable consumption and production patterns**). LIFE OLEA REGENERA contributes to the achievement of sustainable management and efficient use of natural resources and the reduction of waste generation transforming alperujo into valuable byproducts.

In addition, the project helps to fulfil the following Europe strategies:

- European Green Deal Goal 6: Transition to a fair, healthy and environmentally-friendly food system, as the main objective of our project the reduction the environmental impact of the olive oil waste.

- EU Sustainable Development Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation through the optimization process of traditional olive oil production.

8. REPLICABILTY, TRANSFERABILITY AND COOPERATION

The results of the LIFE OLEA REGENERA demonstration actions, the ease of implementation and the European need to reach a solution for the alperujo management problem underpin the great scale-up potential of our solution and naturally drives the replication of the technology to European and even global markets.

To this end, the cooperation with the following partners will be necessary:

- **Vadolivo:** Large company that has been dedicated to the production and processing of olive oil for more than 30 years and is looking for projects and solutions that make its economic activity more environmentally sustainable. Vadolivo owns the olive mill Casa Grande, where the alperujo separator and additional equipment haves been installed, and will be ease the commercialization of the byproducts as animal feed.

- **Nuggest:** Animal feed formulation and distribution company. Orujo Frío, Solex and Casa Grande have signed a collaboration agreement through which Nuggest is committed to being the sole distributor of the Fibroliva by-product.

During the After-LIFE period, commercial alliances will be sought with those strategic partners to set the basis for the commercialisation of the solution.

Best practice lessons

- The inclusion of S1 as animal feed besides S2 has proven to be a good practice, as it allows the complete elimination of the alperujo waste and its transformation into valuable byproducts that can be used as animal feed or biostimulants, thus closing the circle.
- Analysing the toxicity of L3 concentrate before finalising the biostimulant formulations was also a good practice, as determining the maximum amount of HT that the plants can absorb before starting the essays in Action B2 has allowed to overlap the essays, saving time and allowing us to catch up on delays.
- Finally, the study of the concentration of L3 has also been a good practice, as this will allow in the future to reduce the transport costs of this by-product and its packaging.

Innovation and demonstration value

The alperujo separation process has been validated and demonstrated in the Casa Grande olive mill. This process is already able to perform the alperujo drying process and meets the base concept requirements and environmental parameters at the EU regulations framework.
Thus, from a technical point of view, we can consider that the alperujo separation solution has been proven in operational environment and the byproducts are already on the market, so current development stage of our solution is therefore in a Technical Readiness Level 9.

Policy implications

Every year, orujeras have to manage the more than 12,000,000 tons of alperujo that are annually produced resulting from the olive oil extraction process. During the alperujo drying process, the exhaust gases produced in orujeras are expelled to the air through a chimney at such a high temperature and with such a quantity of suspended solids that the existing solutions in the market cannot filter them.

In fact, air pollution is so severe around orujeras that most of them which were located nearby urban places have been closed.

This issue collides with the upcoming environmental regulations in the EU (industrial emissions Directive 2010/75, National Emission Ceilings (NEC) Directive 2016/2284 and specific Directive 2015/2193 for medium combustion plants), which impose severe requirements for industrial emissions reduction, so more orujeras will have to close due to non-compliance with environmental laws and regulations, which jeopardises the continuity of the olive oil sector in Europe.

The solution proposed in LIFE OLEA REGENERA allows the olive oil production industry, of such importance in Europe, not only to continue operating in compliance with environmental regulations, but also to obtain an economic benefit from the processing of the alperujo.

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