

Technical-economic prefeasibility of an olive pomace biorefinery for the main olive-growing areas of Argentina



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Ganadería y Pesca
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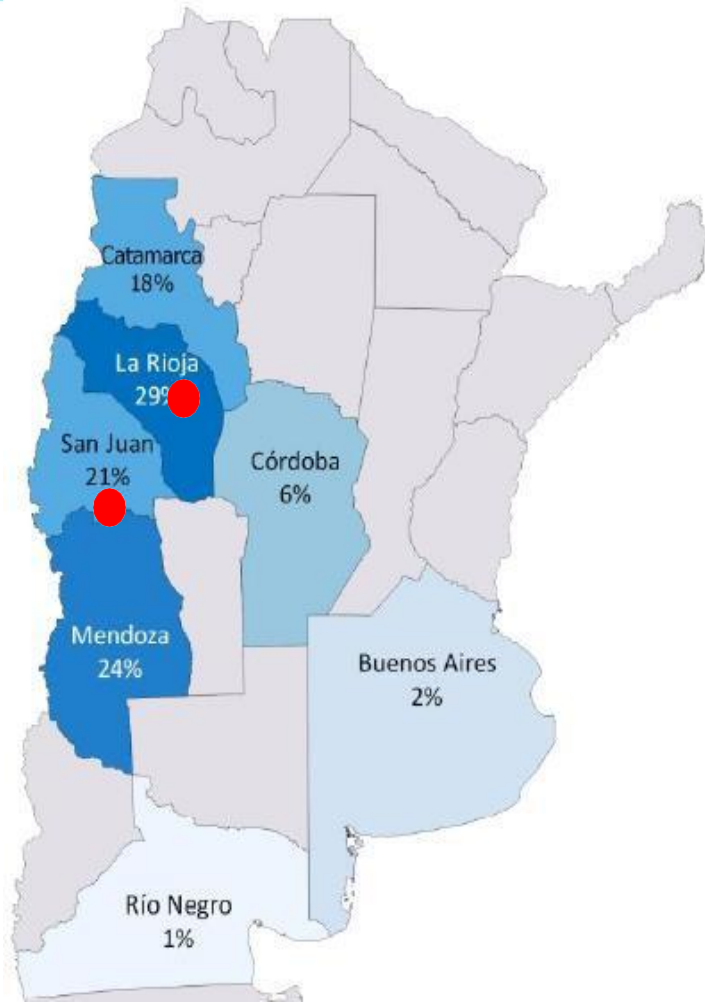
¹ Instituto Nacional de Tecnología Industrial (INTI) – Sede San Juan

Olive sector in Argentina

Argentina is the main olive oil producer among South American countries, with over 250.000 t of olives milled per year

During the last two decades, **two regions** have become the main centers of olive oil production in the country.

- **Sarmiento, San Juan**
- **Chilecito, La Rioja**



Olive sector in Sarmiento and Chilecito

-Main characteristics-

- Large scale intensively managed olive groves
- Modern olive oil industries integrated with primary production
- Oil extraction is performed by two-phase systems. Olive pomace (*alperujo*) is the main olive oil by product.
- Lack of pomace oil extractors

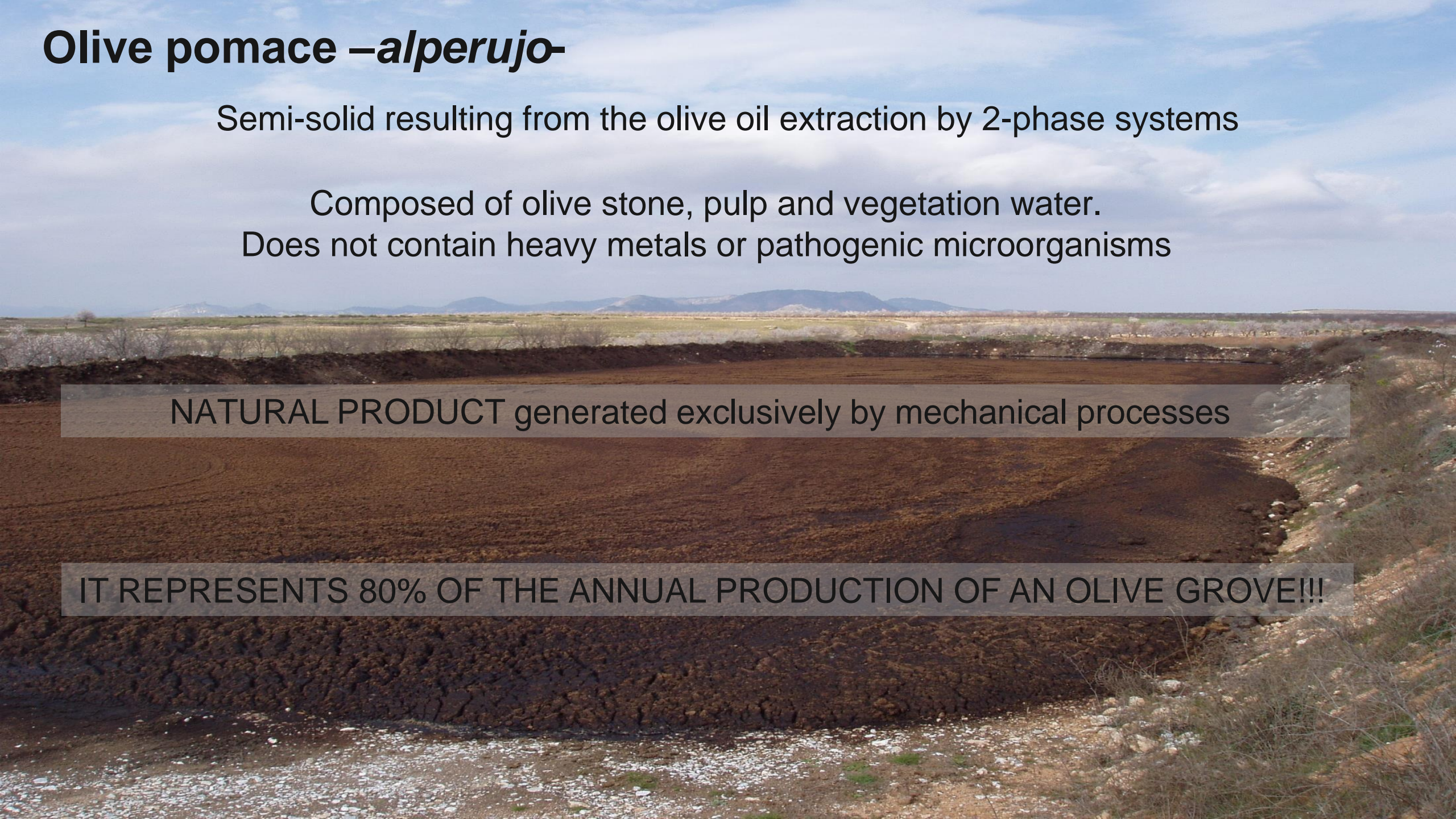
Olive pomace –*alperujo*

Semi-solid resulting from the olive oil extraction by 2-phase systems

Composed of olive stone, pulp and vegetation water.
Does not contain heavy metals or pathogenic microorganisms

NATURAL PRODUCT generated exclusively by mechanical processes

IT REPRESENTS 80% OF THE ANNUAL PRODUCTION OF AN OLIVE GROVE!!!



Difficulties related to pomace management



Environmental

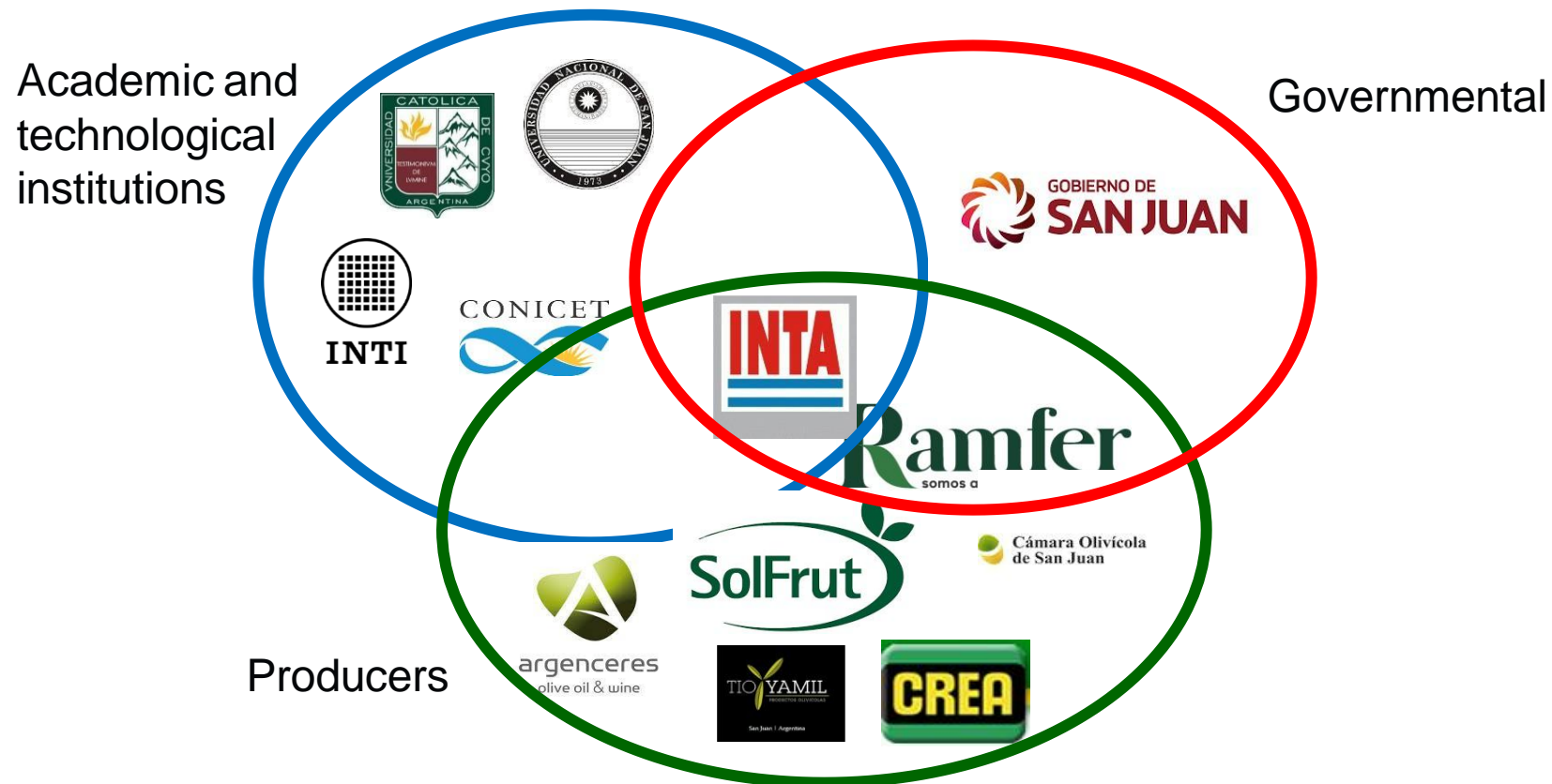
- Risk of pollution of water courses in case of uncontrolled overturning or storage in non-waterproofed ponds.
- Toxic effects on some crops (phenolics).
- Emanation of odors during long-term accumulation.

Logistics/Economic

- Seasonality (high amount in short time period)
- Transportation costs (high water content)

Since 2010, Joint public-private work

- Evaluate practices for *in situ* management of olive pomace
- Generate recommendations



Controlled application
of pomace to the olive
grove soil



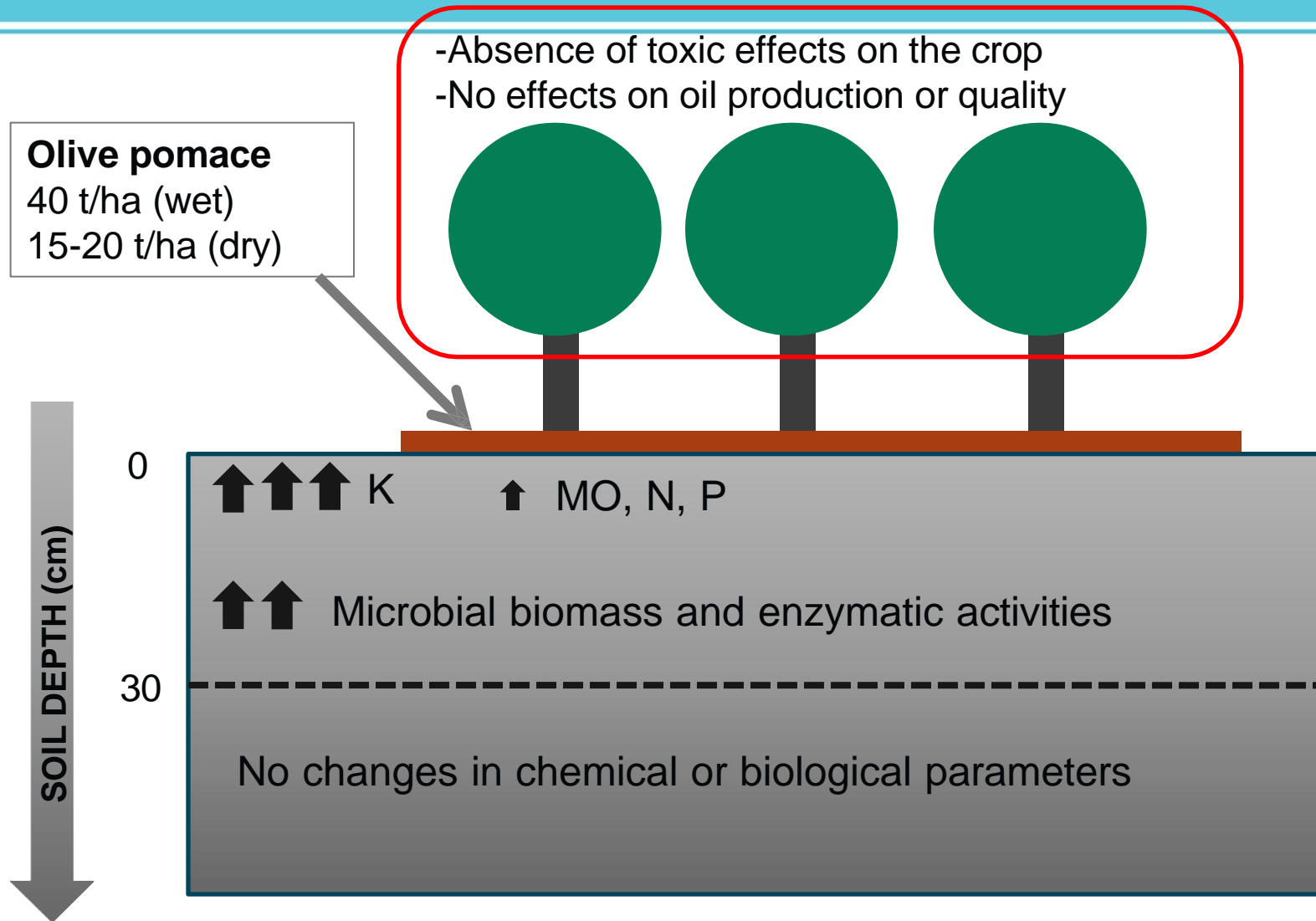
Finca Doña Carmen (el Acequión, San Juan)



Solfrut SA (25 de mayo, San Juan)



Practical recommendations on soil application



Monetta et al, 2012; Monetta et al, 2014; Paroldi et al, 2016; Lorca et al 2016

Composting



(Monetta et al, 2014; Bueno et al, 2014; Martinez et al., 2016)

Composting



Recommendations on:

Critical aspects

- High initial water content
- High phenolic content
- Low particle size

Raw materials for co-composting

- Olive leafs
- Grape stalk
- Goat or chicken manures

Moisture maintenance

- Pressurized irrigation
- Use of covers

Compostaje de Residuos Olivícolas

Pasos para obtener un compost de calidad

- Disponer de una superficie limpia, amplia y plana, preferentemente impermeabilizada (Patio/planta de compostaje).
- Armar camas de contención con material estructurante de aproximadamente 1 o 2 m de ancho y 30 cm de alto, dependiendo de las dimensiones disponibles.
- Descargar los residuos sobre éstas camas a medida que se vayan generando.
- Armar una pila mediante el paso de la máquina volteadora o mediante una pala cargadora frontal. El tamaño de las pilas dependerá de la máquina utilizada pero en general, se realizan de 1-2 m de ancho, 1 m de alto, con longitud variable.

Volteos: Realízalos para promover el ingreso de oxígeno al interior de la pila. Permiten eliminar el exceso de humedad, disminuir la temperatura y homogenizar la composición. Es importante que durante el primer mes exista un control diario de la temperatura mediante un termómetro. Si ésta supera los 65 °C por más de 24-48 h, es necesario realizar un volteo. Una mayor frecuencia favorecerá el proceso de oxidación de la materia orgánica y acelerará los tiempos de compostaje. Se sugiere comenzar con un volteo semanal durante los dos primeros meses, para luego disminuir a uno cada quince días, hasta alcanzar la madurez.

Riego: La humedad interna de la pila debe mantenerse entre 40-50%, a través de la implementación de un sistema de riego (cisterna, sistema presurizado, etc.). La lámina a aplicar dependerá de las condiciones climáticas de la región, por ejemplo, el control de la humedad es clave en épocas de viento zonda con altas temperaturas.

Contactos

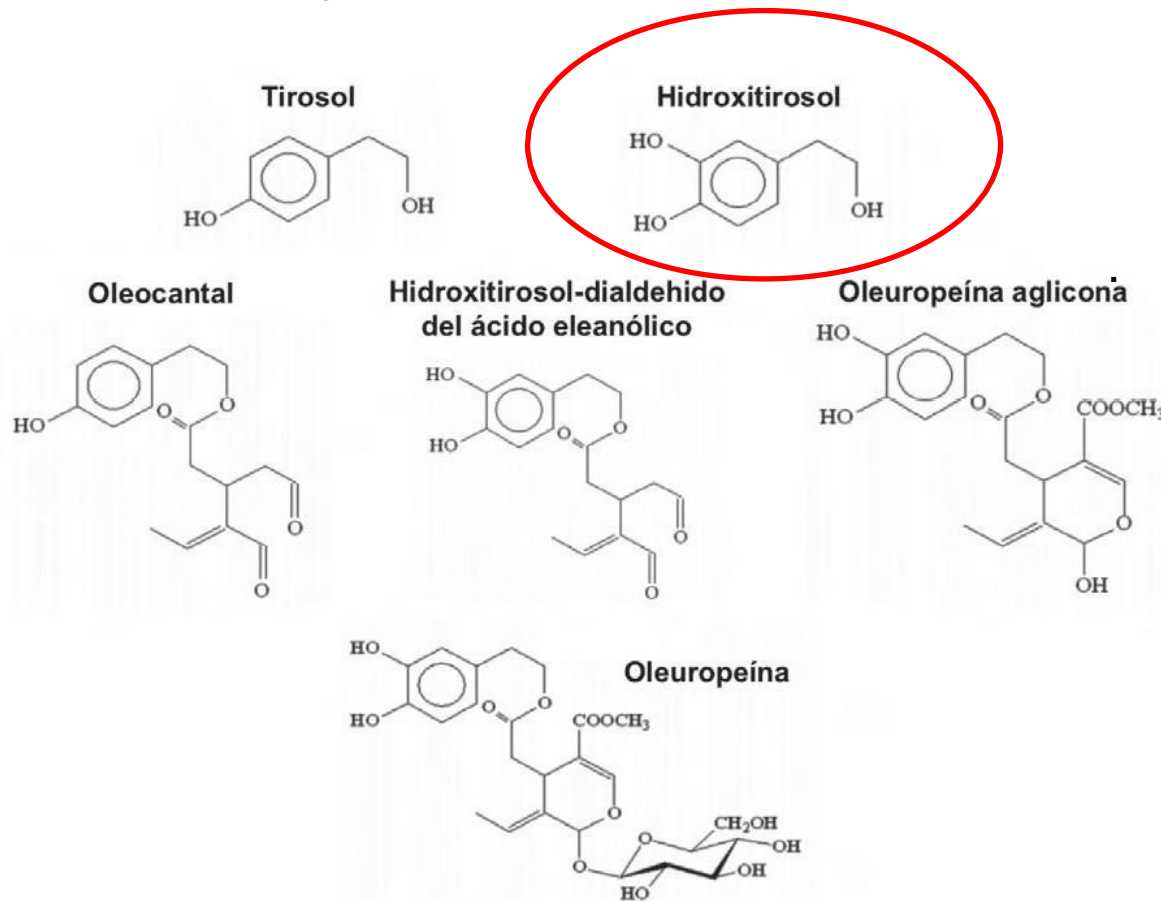
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PNNAT 1128042
Tecnologías y estrategias de gestión de residuos y efluentes en sistemas agropecuarios y agroindustriales

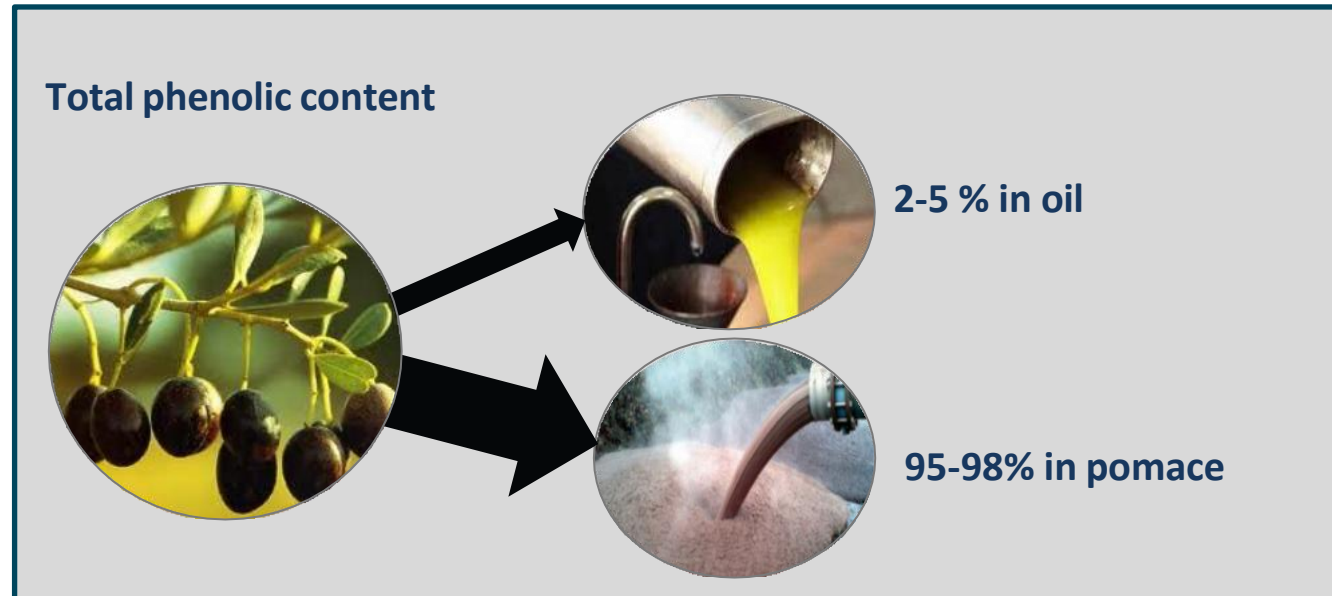
Recovery of Phenolic compounds

Olive **PHENOLIC COMPOUNDS** include a large group of complex and simple phenols, in which **HYDROXYTHYROSOL** stands out for its high **ANTIOXIDANT activity**.



HT: Hydrophilic phenol, with reported **health benefits** and promising **technological properties** for the cosmetic, pharmaceutical, food industries.

Olive phenols distribution



(Owen et al., 1998)

Olive pomace represents an attractive **source of phenolic compounds** and **HT**

Work strategy

Collaborative work with Fat Institute-CSIC
Leading research group in this field



Phenolic compounds recovery in 2 consecutive stages

1. Thermal treatments to olive pomace



Phenolic enriched liquid fractions

2. Adsorption columns



Highly concentrated phenolic extracts

(Fernandez Bolaños et al., 2002; Rodriguez Gutiérrez et al., 2007; Rubio Senent et al., 2013; Lama et al., 2019;.....)

**Collaborative
work aim**



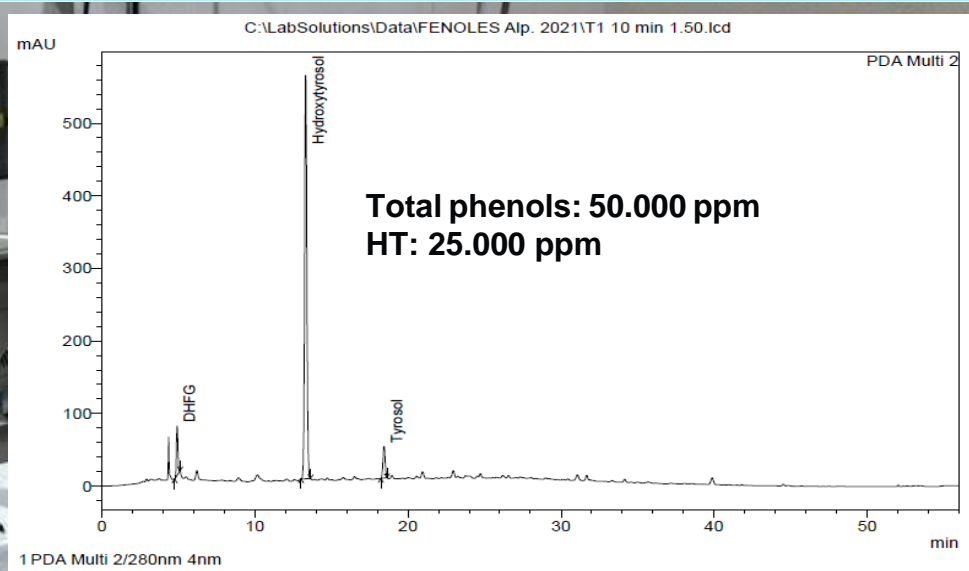
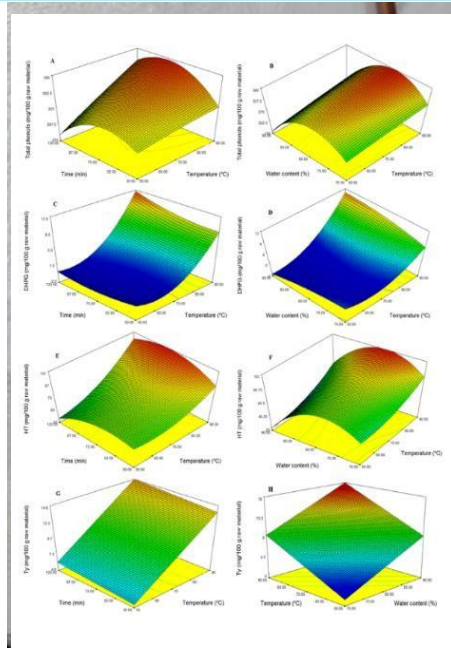
**Adapt the proposed process for
implementation with standard olive
mill equipment**



**Facilitate
industrial
adoption**

Process implementation with olive oil equipment (200kg/h)

(Rodríguez Márquez et al., 2023; Rodríguez Márquez et al., 2024)



ANTIOXIDANTES NATURALES DEL OLIVO

LÍQUIDO

Producto: extracto biofénolico rico en hidroxitirosol (HT)

Descripción del producto:

Características funcionales: Actividad antioxidante. El HT presenta actividad antioxidante igual o superior a otros compuestos conocidos como la vitamina E, vitamina C y el butilhidrotolueno (BHT). Además, posee actividad antimicrobiana y antiinflamatoria.

Características organolépticas: Color: pardo oscuro. Olor: Acetunas. Sabor: Amargo.

Características fisicoquímicas: Base acuosa, *Brix: 40-50, pH: 3,5-4,0, Fenoles totales: 45-50 g/L, HT 20-30 g/L.

Materia prima: alperujo, subproducto de la extracción de aceite de oliva.

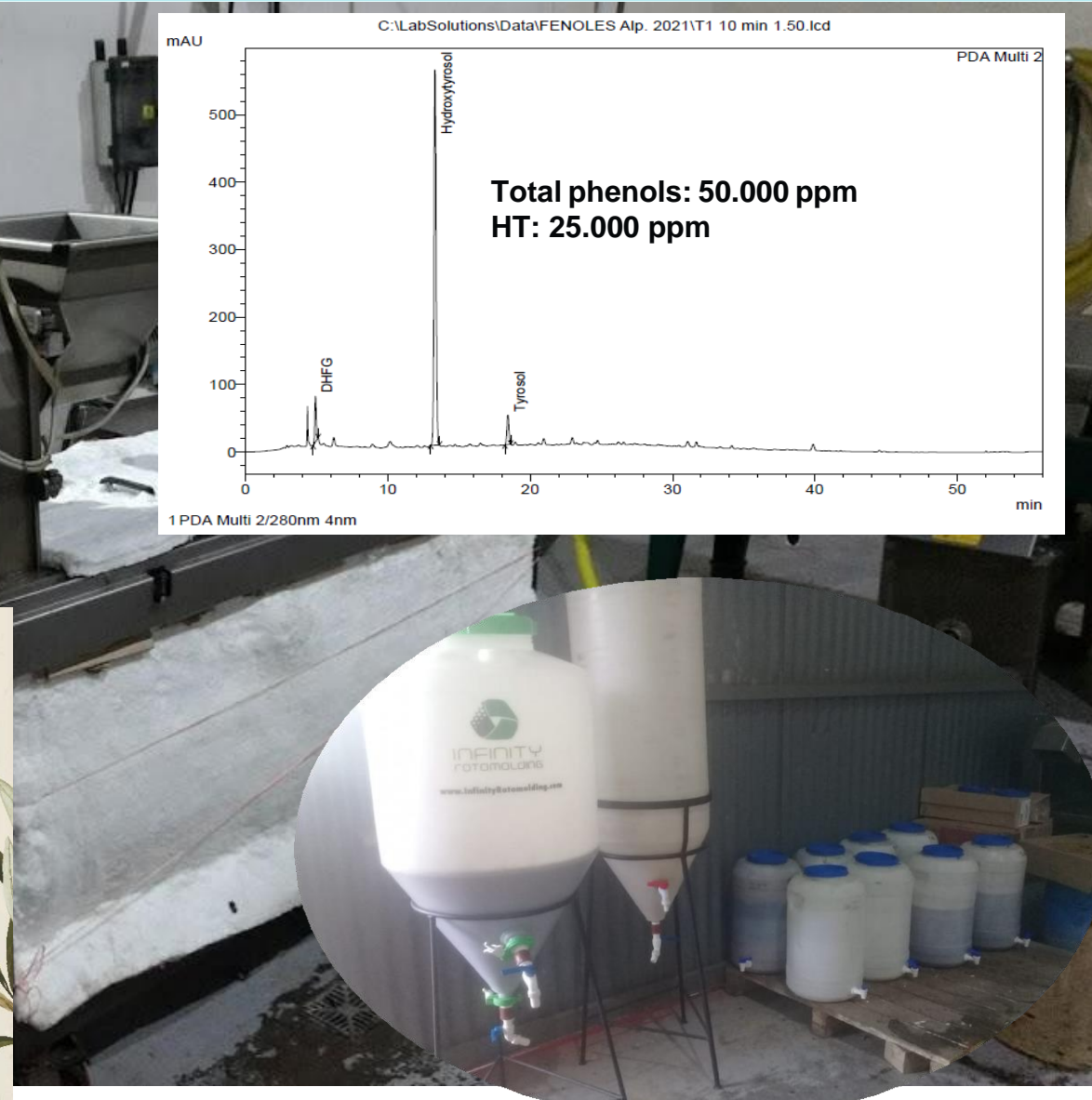
Proceso de obtención: Tratamiento térmico, centrifugación, adsorción y concentración.

Usos potenciales:

- Alimentos funcionales
- Alimentos balanceados
- Conservación de alimentos
- Nutracéutica
- Cosmética

Biofenoles del olivo (HT)

Logos: INTI, INTA



General scheme of the olive pomace biorefinery



Is there interest on the part of the olive industries?

Is there enough pomace in the region?

Is this process feasible?

Is this process economically viable?

Technical-economic prefeasibility of an olive pomace biorefinery in Argentina

Survey of olive industries in Chilecito (LR) and Sarmiento (SJ)

- Geolocation
- Pomace generation (2022 and 2023)
- Needs and expectations regarding pomace valorization practices.

Pomace generation in both regions (2022 and 2023)

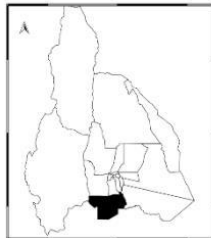
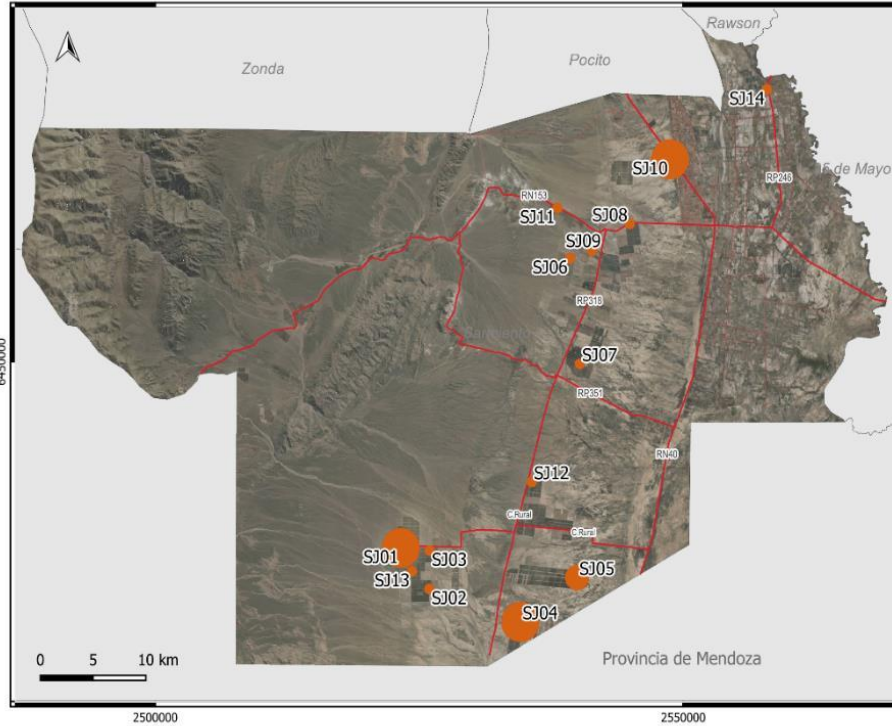
Sarmiento, SJ			Chilecito, LR		
Industry code	2022	2023	Industry code	2022	2023
	Pomace (t)	Pomace (t)		Pomace (t)	Pomace (t)
SJ01	12800	16000	LR01	6400	8800
SJ02	2800	2800	LR02	12000	12000
SJ03	3040	4000	LR03	4800	4400
SJ04	17600	17600	LR04	6400	12400
SJ05	6000	8800	LR05	9600	6400
SJ06	4800	4800	LR06	12000	12000
SJ07	960	2800	LR07	2800	3600
SJ08	2000	4800	Total	54000	59600
SJ09	1760	2400			
SJ10	0	17600			
SJ11	640	800			
SJ12	2800	2400			
SJ13	1680	1440			
SJ14	720	1200			
Total	57600	87440			

Sarmiento: 14 industries - 80.000 t
 Chilecito: 7 industries - 60.000 t
 Growing trend in both regions

Geolocation of pomace generation



GENERACIÓN DE ALPERUJO ESTIMACIÓN CAMPAÑA 2023 DEPARTAMENTO SARMIENTO SAN JUAN



Provincia de San Juan
Dpto. Sarmiento

Fuente cartográfica:
Atlas Socioeconómico de la
Provincia de San Juan- IINSA

Referencias

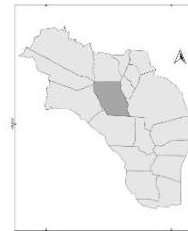
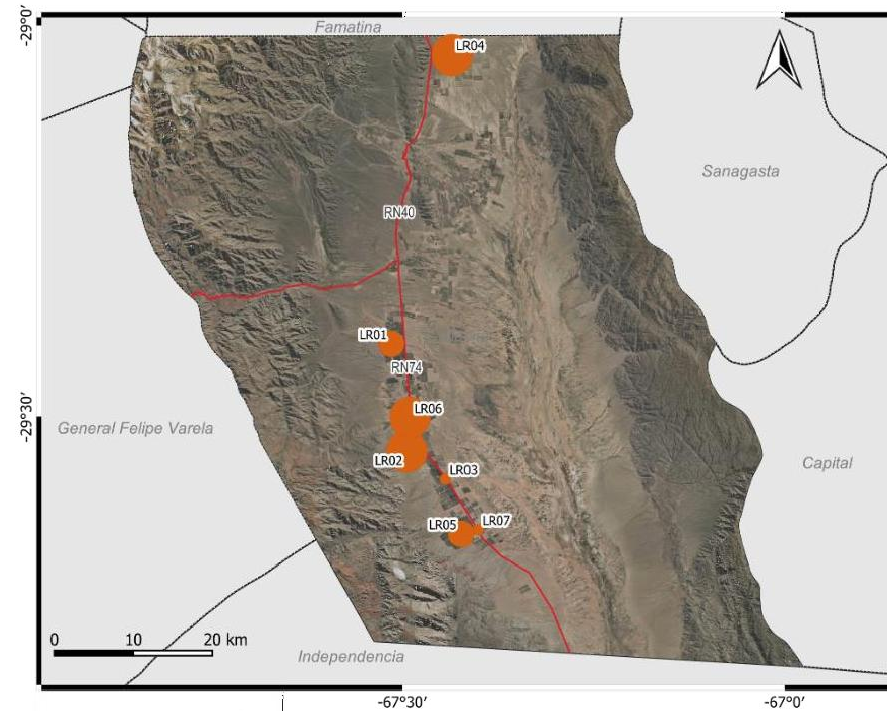
Generación de Alperujo (t)

- 0 - 5999
- 6000-11999
- 12000 - 18000
- Red vial
- División política
- Imagen ESRI Satellite

Elaboración:
Equipo de Innovación.
Biorrefinería de Alperujo
Mayo 2023



GENERACIÓN DE ALPERUJO ESTIMACIÓN CAMPAÑA 2023 DEPARTAMENTO CHILECITO LA RIOJA



Provincia de La Rioja
Dpto. Chilecito

Fuente cartográfica:
"IGN" CapasSIG
Marco de Referencia

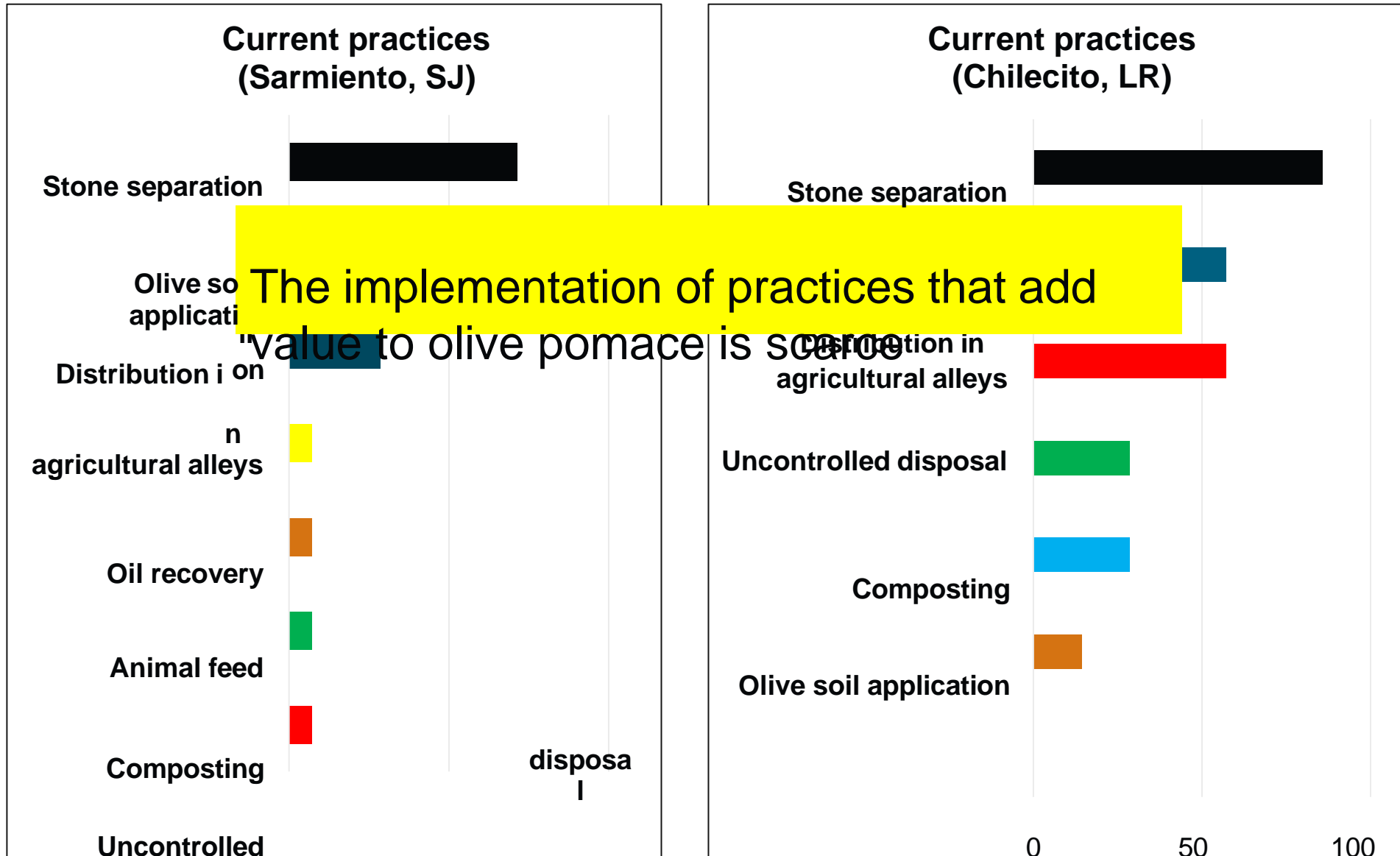
Referencias

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Elaboración:
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Biorrefinería de Alperujo
Mayo 2023

Practices currently being implemented for the management of pomace



Animal feed

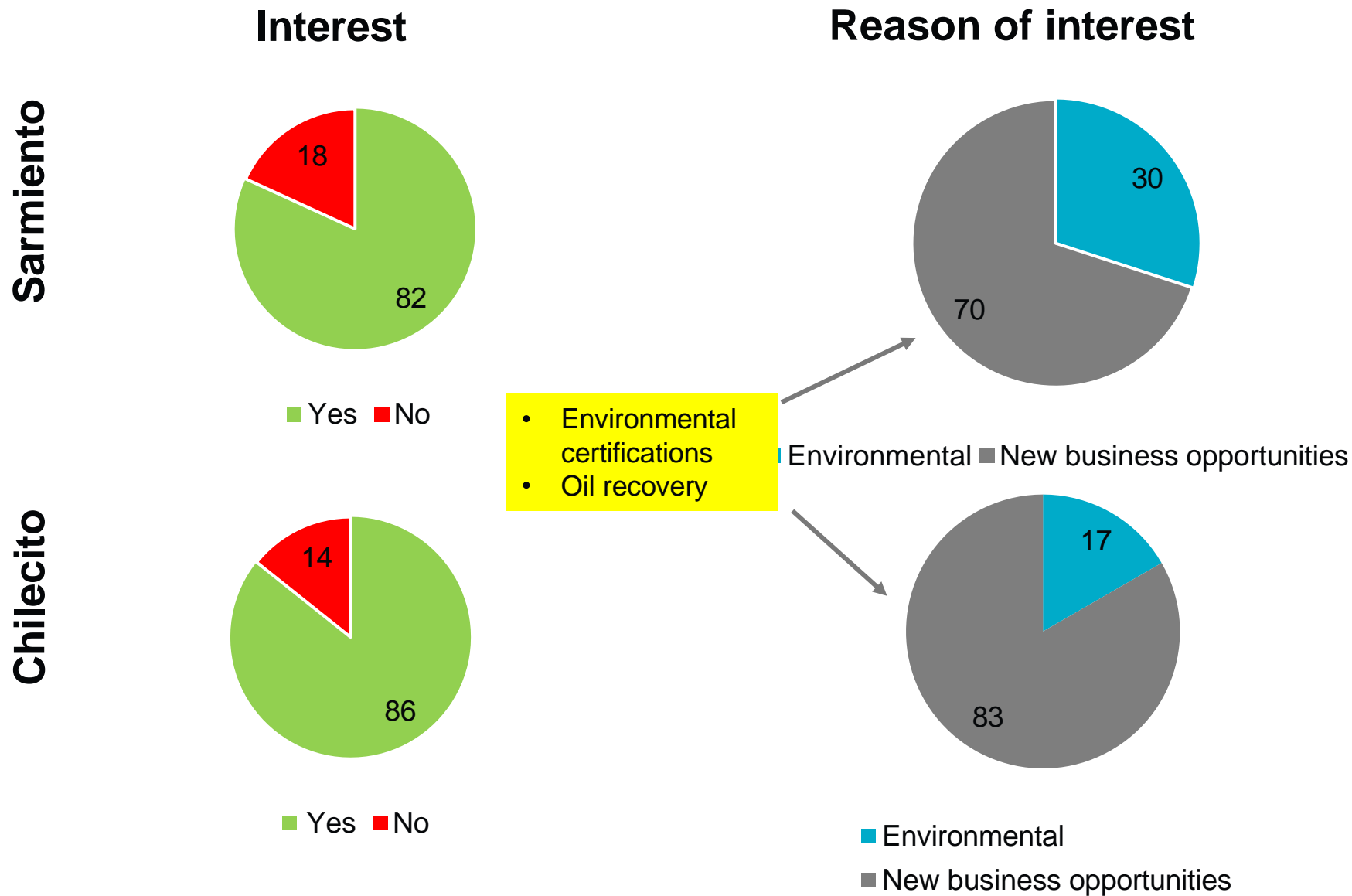
Oil recovery

0

50

100

Interest in new practices for the valorization of pomace



Partial conclusions of survey

- Olive pomace is **generated on a large scale** and shows a growing trend in both regions.
- The **proximity of the industries** favors the availability of this input, one of the determining factors for its implementation.
- The implementation of practices that add value to alperujo is scarce
- Most industries showed **interest in new business opportunities** based on the valorization of pomace.

General assumptions and considerations for de study

- Obtained products, uses, and price
- Flowsheet design
- Mass balance

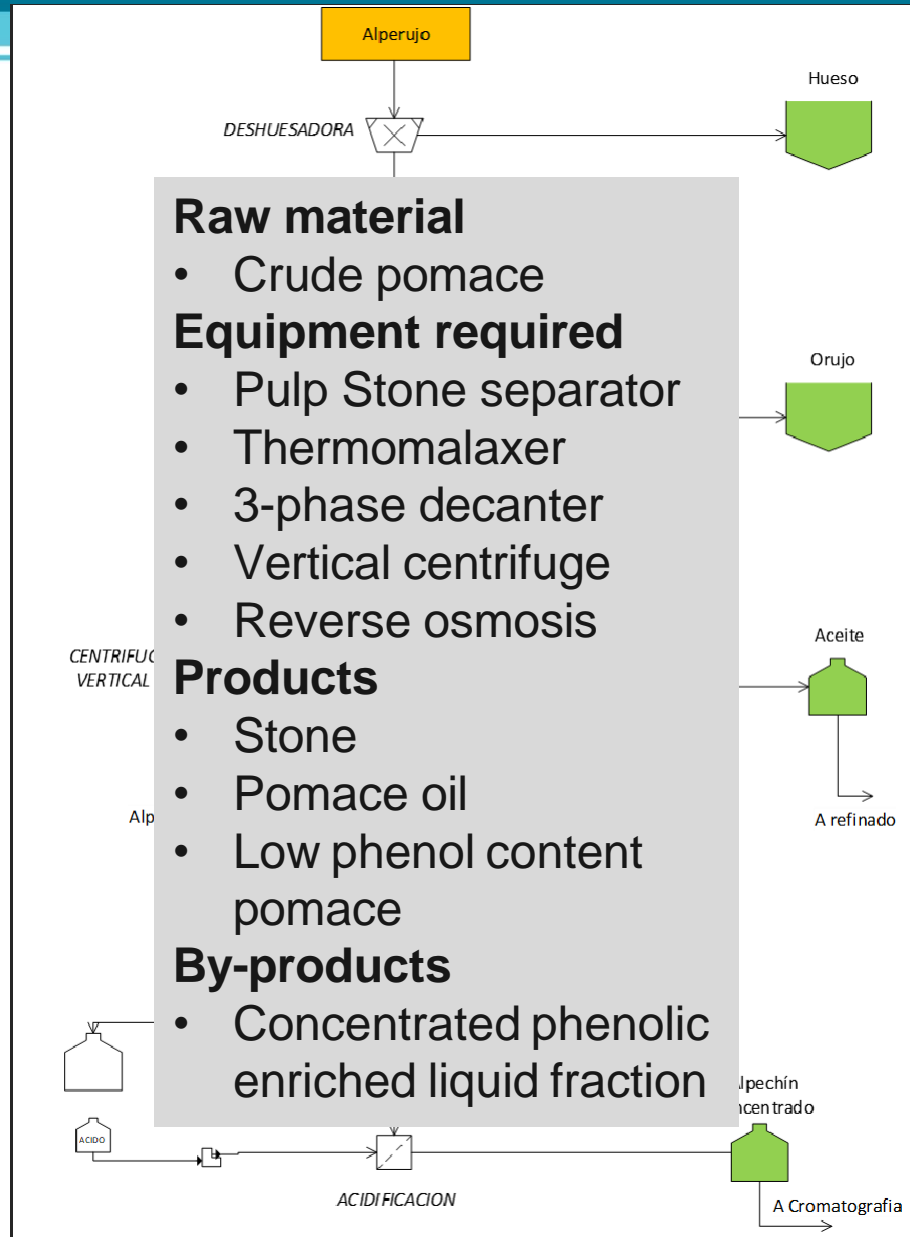
Products, use and prices considered

Product	Characteristics	Use	Price (USD)
Ground stone	Water content <10%; Particle size 2-3 mm; calorific value 4000-5000 Kcal/kg	Solid fuel	39 USD/t
Pomace oil	Acidity > 2%	Refining process	75% of VOO price*
Low phenolic content Pomace	Water content 40-50%; pit <2% w/w: total phenols <1000 mg/L	Animal feed: source of fibers	20 USD/t
Phenolic extract	pH 3.5-4.0; total phenols 50,000 mg/L, HT 20-30,000 mg/L	Antioxidant for animal feed manufacturers	10 USD/L

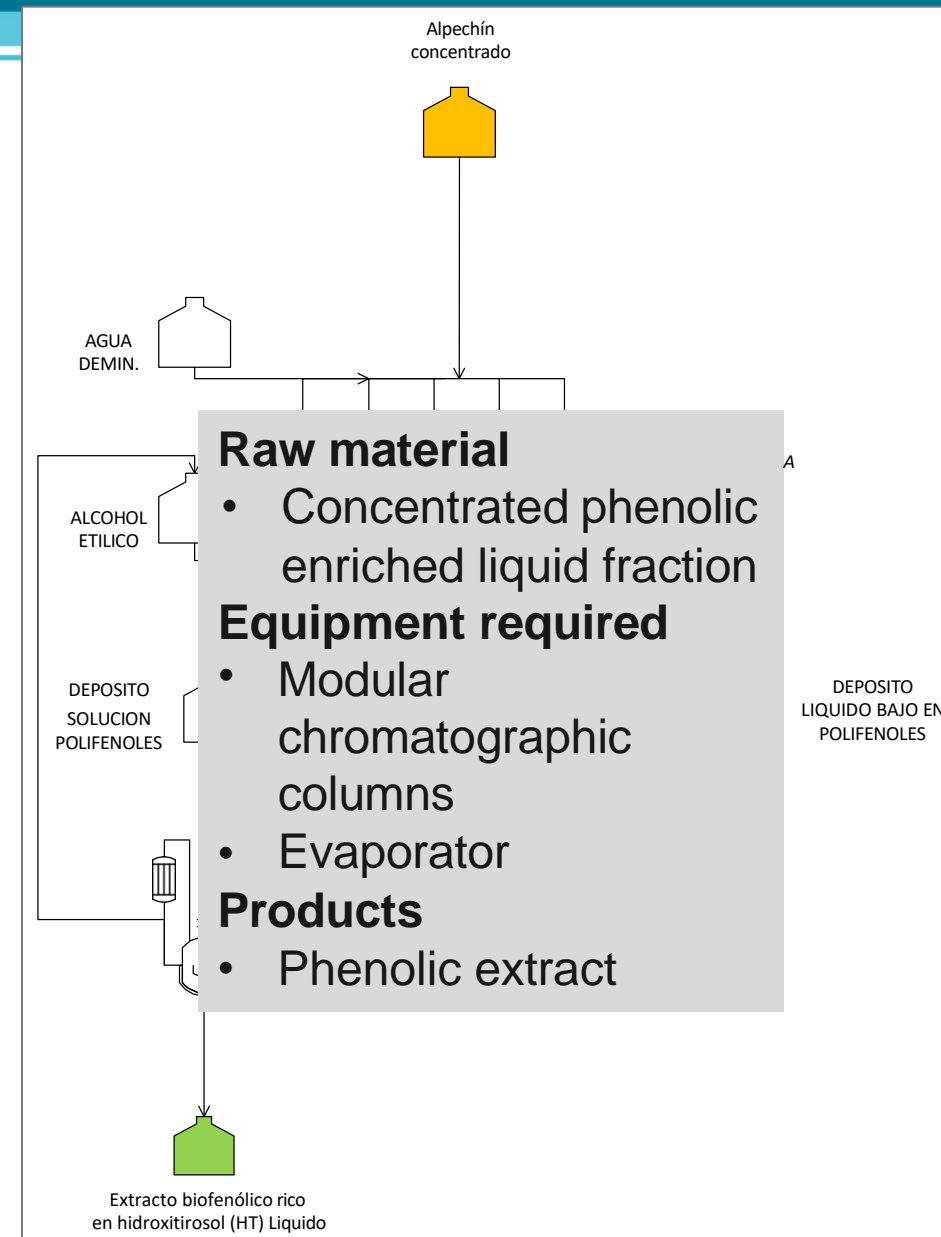
Flowsheet Design

Decoupling of the initial process into
two consecutive processes based
on technological complexity

Process 1 “Physical treatment of pomace”



Process 2: “Chromatographic separation of phenols”



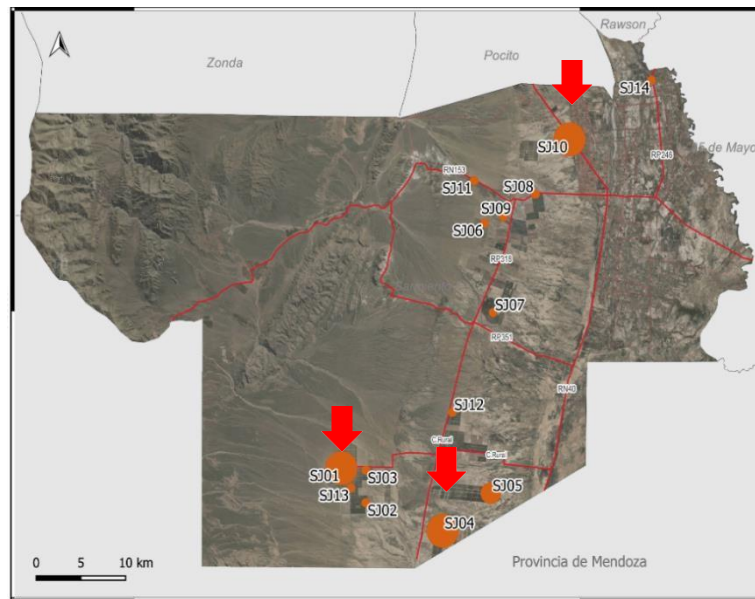
Sceneries

Scenery 1. Olive oil industry that process its own pomace.

Operational capacity: 20.000 t/year

S1.1-Acquisition of a complete production line and operation in parallel to oil extraction

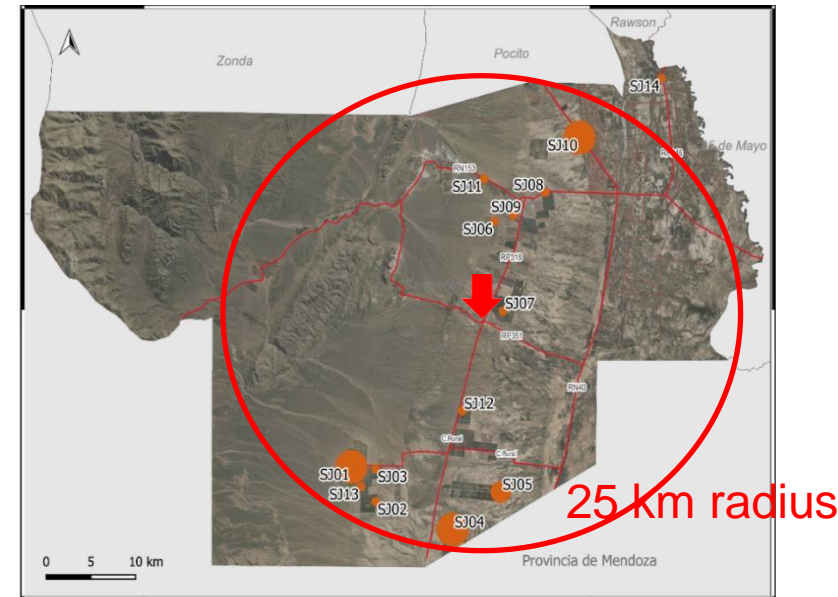
S1.2-Use of existing equipment during periods of inactivity.



Scenery 2. Industry that receives pomace from olive oil industries

Operational capacity: 80.000 t/year

S2-Acquisition of a complete production line and operation in parallel to oil extraction.



Mass balance for both processes and sceneries

Process 1 “Physical treatment of pomace”

Mass balance -Process 1-			
Scale (t/d)	72		240
Operation time (d)	330	250	330
Operational capacity (t of pomace/year)	23 760	18 000	79 200
Stone (t)	3 564	2 441	11 880
Pomace oil (t)	238	200	792
3-phase pomace (t)	11 736	7 958	39 118
Concentrated phenolic enriched liquid fraction (m³)	4 111	3 084	13 705

Process 2 “Chromatographic separation of phenols”

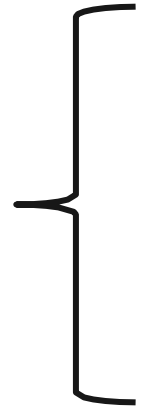
Balance de masa Proceso 2		
Scale (m ³ /d)	14	45
Operation time (d)	300	300
Operational capacity (m ³ of concentrated PELF/year)	4 100	13 500
Phenolic extract (m³/year)	240	814

Economic-financial viability

CAPEX
Capital Expenditures

OPEX
Operational
expenditures

10-year fund flows



International olive oil price

Optimistic: 5000 USD/t

Average: 3500 USD/t

Pessimist: 2000 USD/t

Economic-financial viability analysis

Indicator	Unit	Viable	Conditioned to case study	Not viable
Net present value (NPV)	USD	>1.000.000	999.999-500.001	<500.000
Internal Rate of Return (IRR)	%	>60	59-41	<40
Return on invested capital (ROIC)		>0.95	0.94-0.51	<0.50
Investment Recovery Period (IRP)	Years	<10	N/A	>10

The viability criteria of the financial indicators were agreed with the local olive sector for the year 2023 in Argentina

Results of the economic-financial analysis

Scenery 1. Olive oil industry that process its own pomace.

S1.1-Acquisition of a complete production line and operation in parallel to oil extraction

S1.2-Use of existing equipment during periods of inactivity.

Operational capacity: 20.000 t/year

Scenery 2. Industry that receives pomace from olive oil industries

S2-Acquisition of a complete production line and operation in parallel to oil extraction.

Operational capacity: 80.000 t/year

Process 1

Investment: USD 1 430 822			
International olive oil price			
Indicator	2000	3500	5000
IRR (%)	10	25	33
NPV (USD)	420 488	747 883	1 075 685
ROIC	0,3	0,5	0,7
IRP (years)	>10	>10	>10

Investment: USD 864 993			
International olive oil price			
Indicator	2000	3500	5000
IRR (%)	35	59	76
NPV (USD)	585 729	941 217	1 194 013
ROIC	0,6	1,0	1,3
IRP (years)	>10	6	3

Investment: USD 2 059 710			
International olive oil price			
Indicator	2000	3500	5000
IRR (%)	37	66	94
NPV (USD)	1 498 094	2 590 767	3 683 439
ROIC	0,6	1,1	1,6
IRP (years)	>10	5	2

Process 2

Investment (USD)	
2 056 135	
Conc. PELF (m ³ /year)	4 100
IRR (%)	51
NPV (USD)	1 667 508
ROIC	0,8
IRP (years)	7

Investment (USD)	
3 093 783	
Conc. PELF (m ³ /year)	13 500
IRR (%)	110
NPV (USD)	6 460 661
ROIC	2,1
IRP (years)	2

Main conclusions: Technological feasibility

Process 1 “Physical treatment of pomace”:

- Low complexity equipment.
- Infrastructure and equipment are available in a standard olive industry.
- Can be operated by workers operating olive oil industries.

Process 2 “Chromatographic separation of phenols”:

- Greater complexity of acquisition and operation.
- Some equipment must be purchased from foreign companies.
- Requires workers trained in this technology.

Main conclusions: Economic-financial viability

Process 1, “Physical treatment of pomace”

- On its **largest scale**, it presented **favorable indicators** in medium and optimistic contexts of olive oil prices.
- On its **lower scale**, it presented **favorable indicators** only when **existing equipment was used**.

Process 2, “Chromatographic separation of biophenols”

- On its **largest scale**, presented **promising economic and financial indicators**, far exceeding standard expectations for investments in this type of project.

General conclusion

The installation of **pomace biorefineries** in these two productive poles of the **Argentine olive basin** presents **technical feasibility** and broadly **favorable economic indicators** some of the scenarios described above.

We are currently working with case studies to improve the precision of the proposal and allow the project to represent a real contribution to the olive oil sector sustainability

Teamwork

Coworkers and collaborators:

Manuel Rodríguez Márquez, Luis Bueno, (INTA San Juan)

Guillermo Rodríguez Gutiérrez (IG-CSIC, Sevilla)

Cristina Deiana, Marianela Giménez (IIQ-UNSJ)

Personnel from olive industries that open their doors to us to conduct interviews and rehearsals



FACULTAD DE INGENIERÍA

Thanks for your attention

Muchas gracias por su atención

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Ministerio de Agricultura,
Ganadería y Pesca
Argentina