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

INTERNATIONAL OLIVE SUSTAINABILITY CONFERENCE

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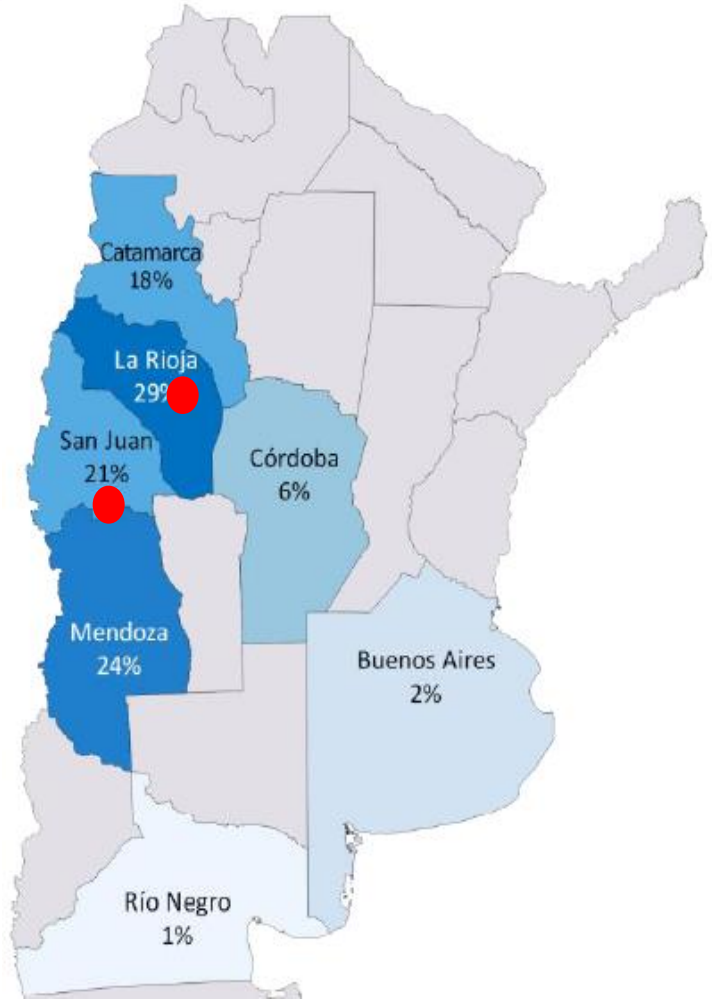
Olive sector in Argentina



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

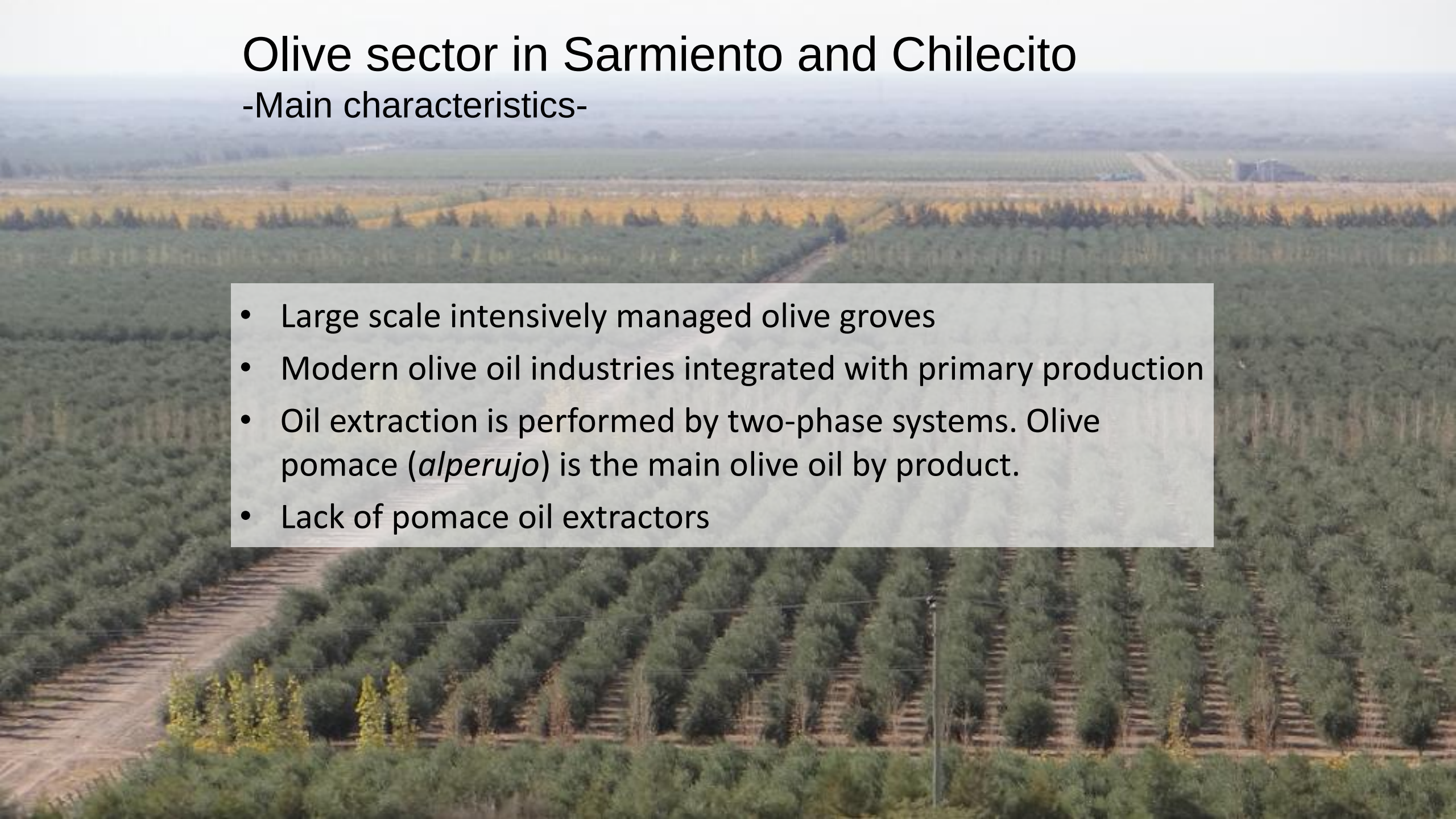
During the last two decades, **two regions** have become the main centers of olive oil production in the country.

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

*CNA 2018

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

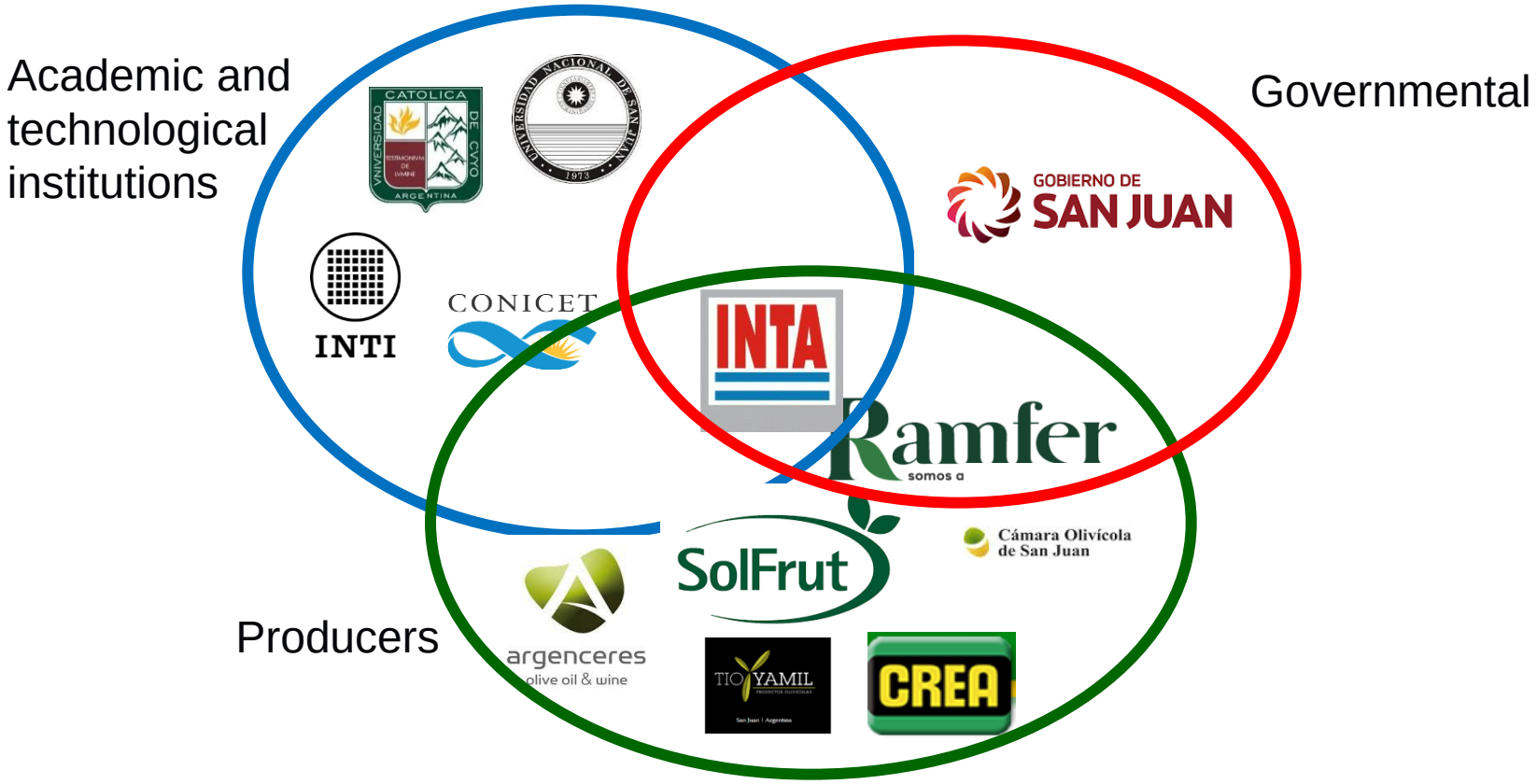
- Risk of pollution of water courses in case of uncontrolled overturning or storage in non-waterproofed ponds.
- Toxic effects on some crops (phenolics).
- Emanation of odors during long-term accumulation.

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

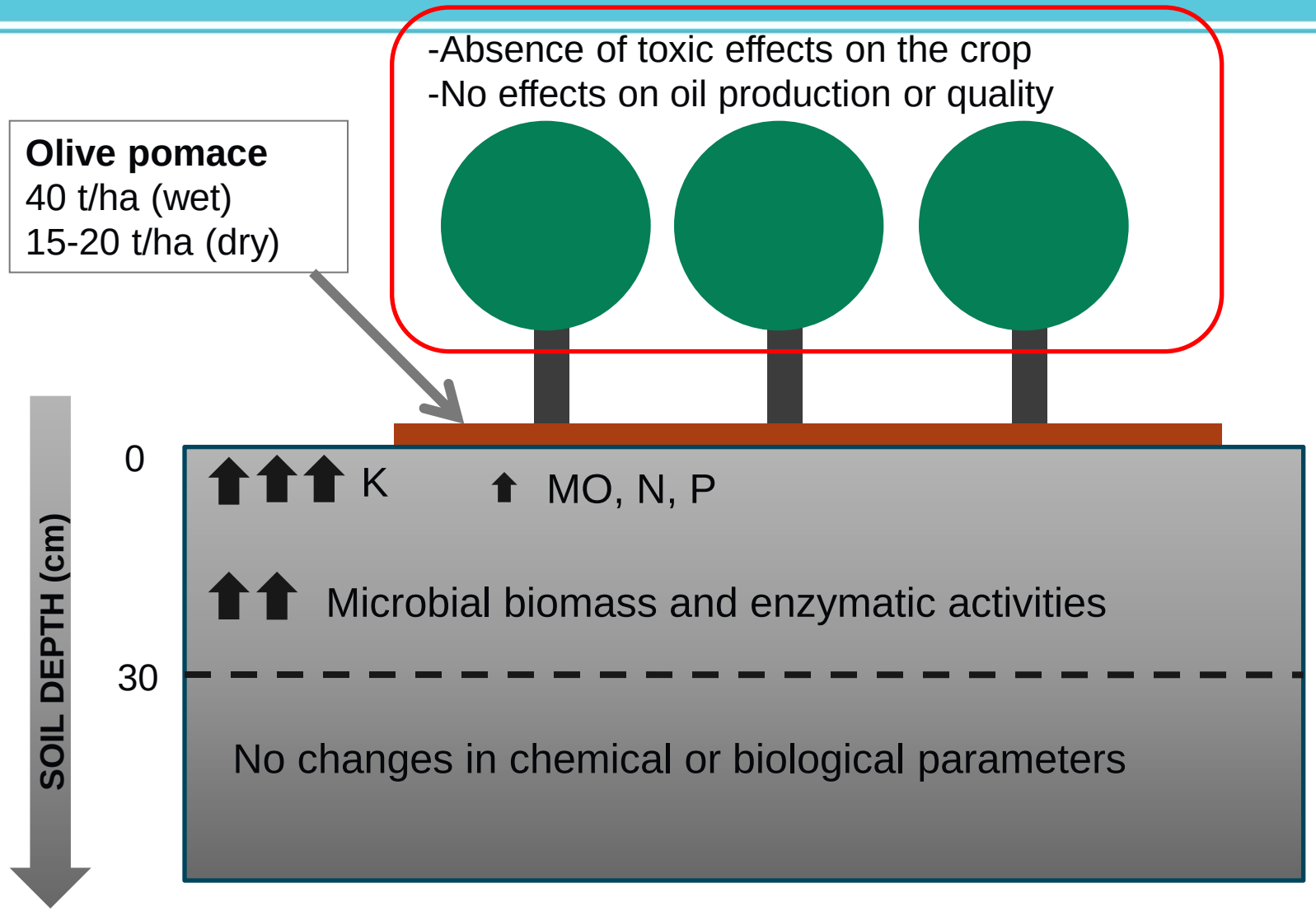



Controlled application
of pomace to the olive
grove soil

Finca Doña Carmen (el Acequión, San Juan)

Solfrut SA (25 de mayo, San Juan)

Practical recommendations on soil application

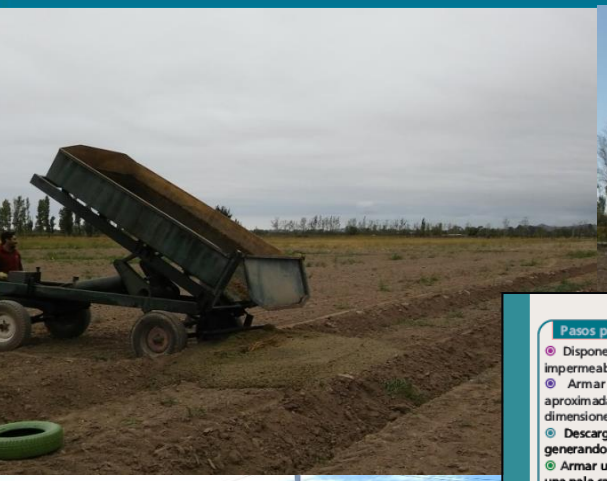


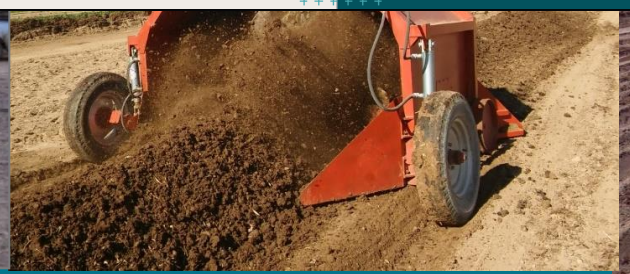
Monetta et al, 2012; Monetta et al, 2014; Paroldi et al, 2016; Lorca et al 2016

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

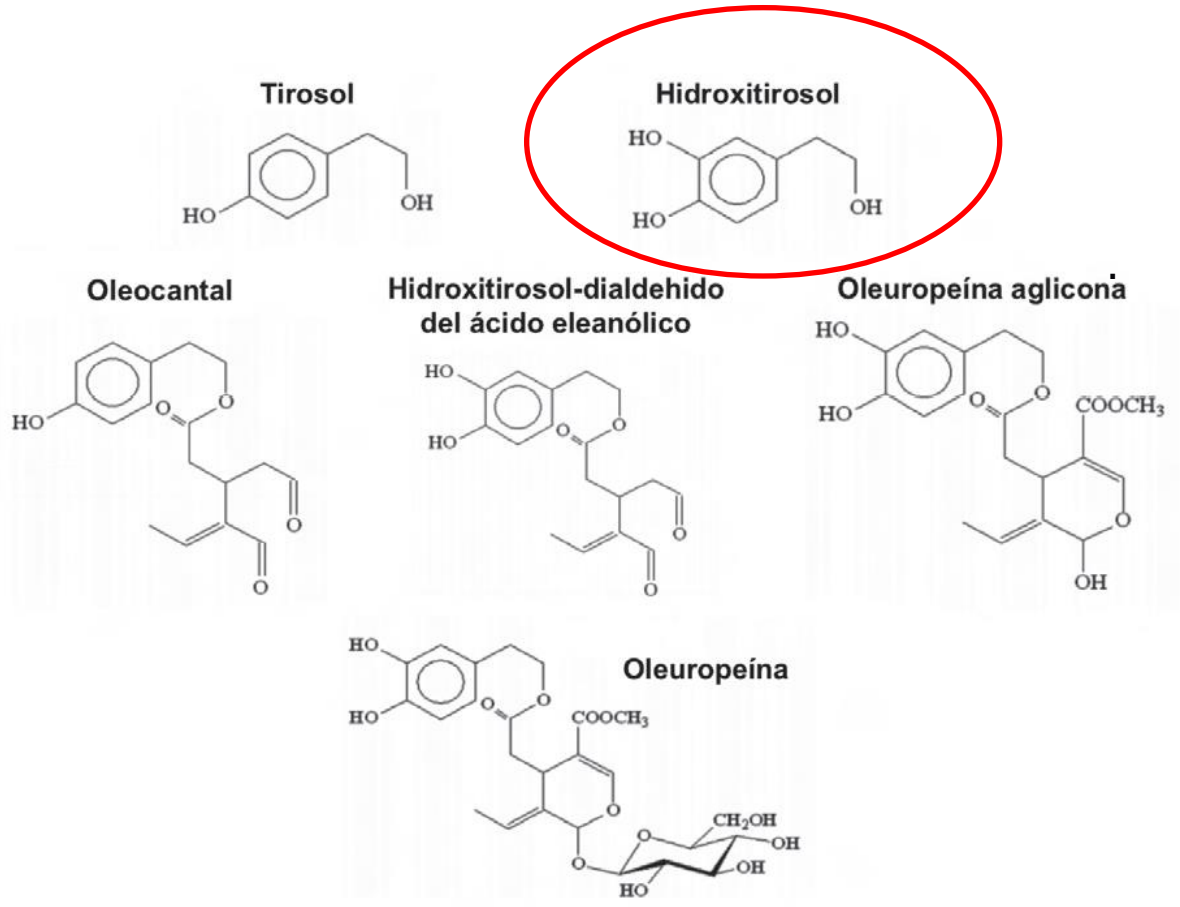
- Olive leafs
- Grape stalk
- Goat or chicken manures

Moisture maintenance

- Pressurized irrigation
- Use of covers

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

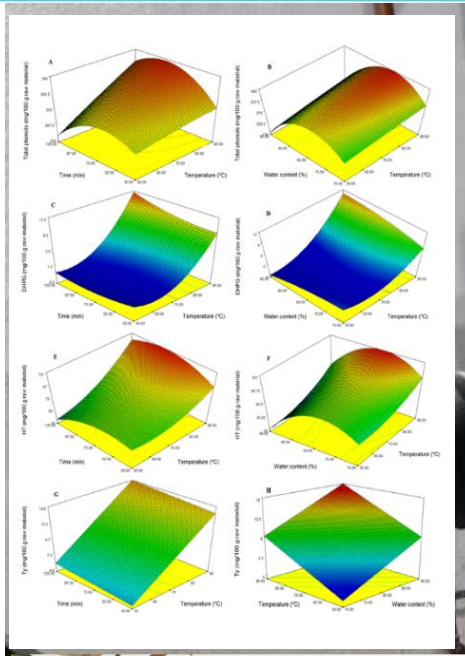
1. Thermal treatments to olive pomace → Phenolic enriched liquid fractions
2. Adsorption columns → Highly concentrated phenolic extracts

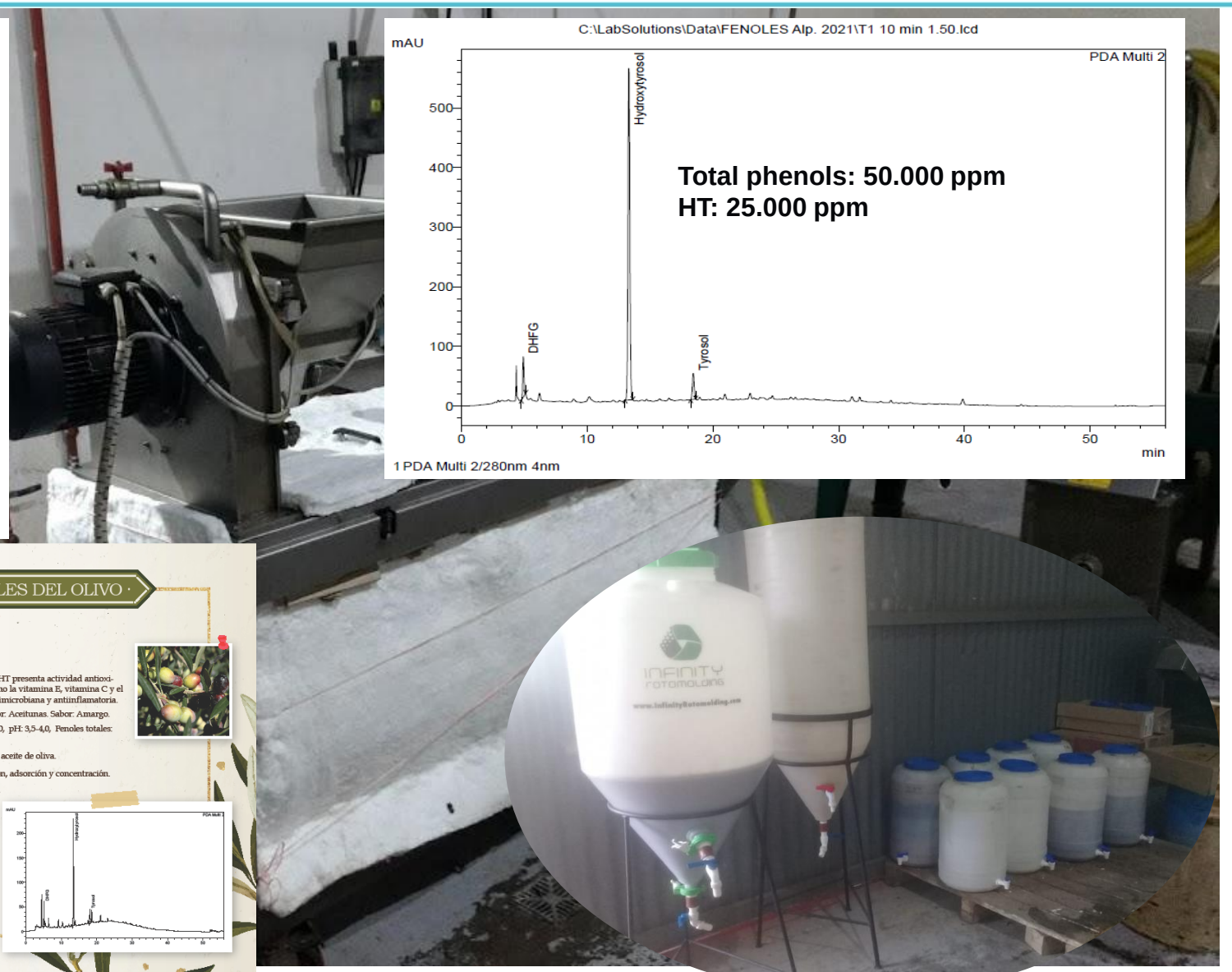
(Fernandez Bolaños et al., 2002; Rodriguez Gutiérrez et al., 2007; Rubio Senent et al., 2013; Lama et al., 2019;…….)

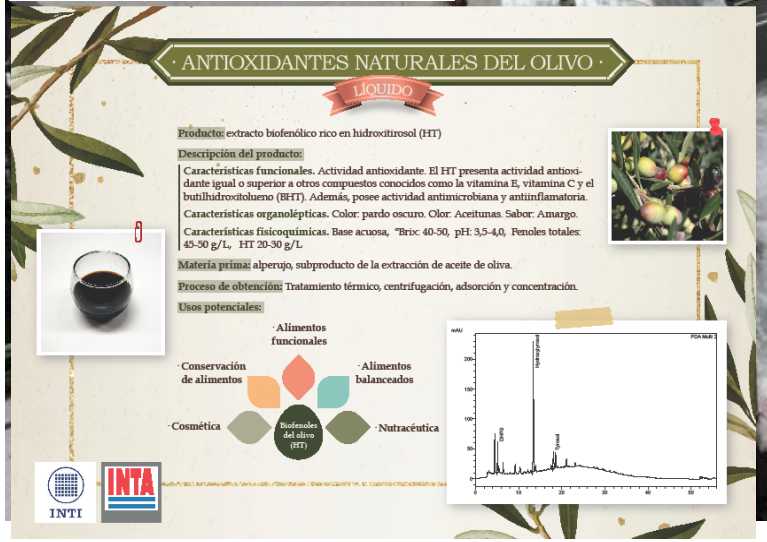
Collaborative work aim → **Adapt the proposed process for implementation with standard olive mill equipment** → **Facilitate industrial adoption**

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

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







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.

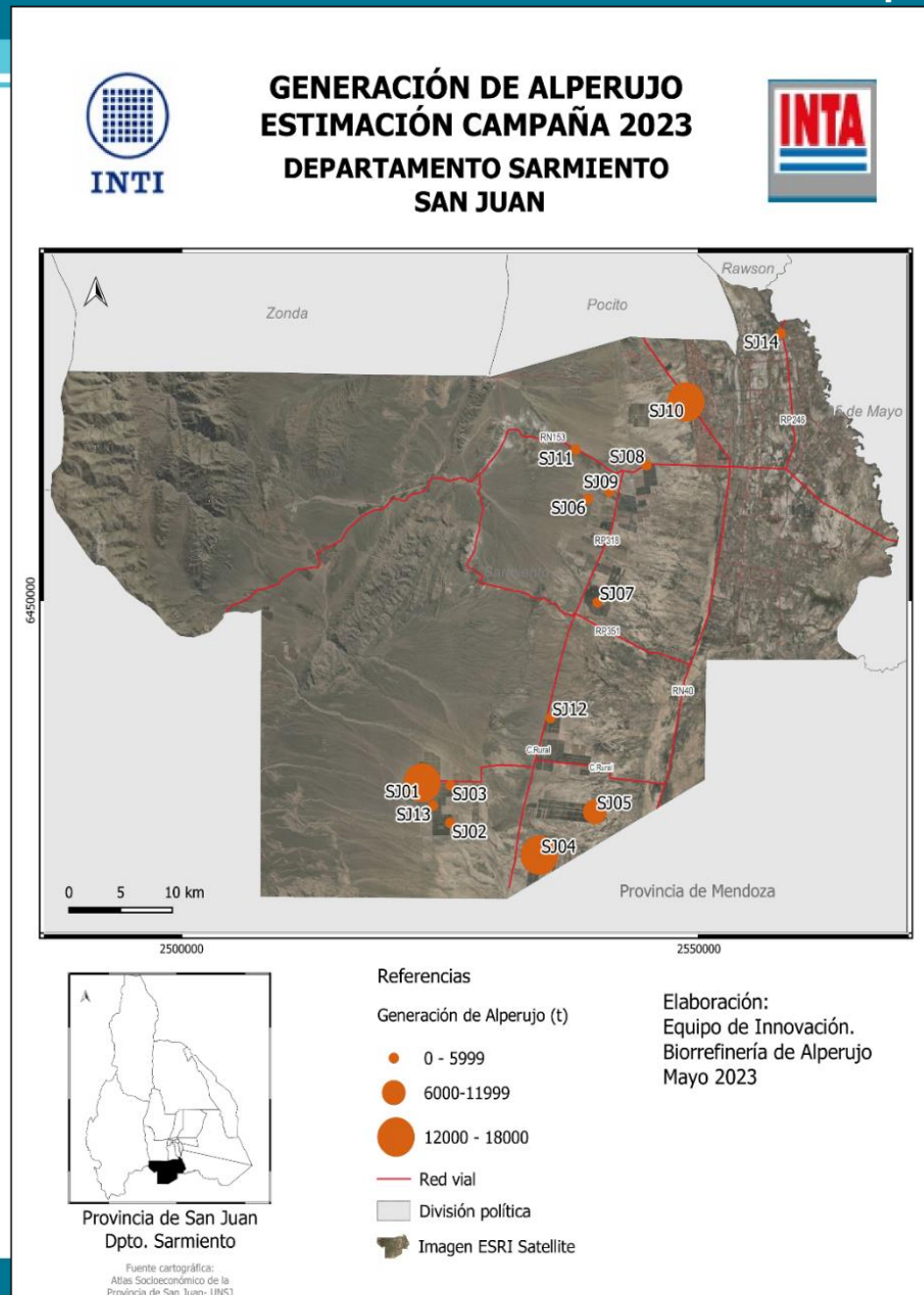
Pomace generation in both regions (2022 and 2023)

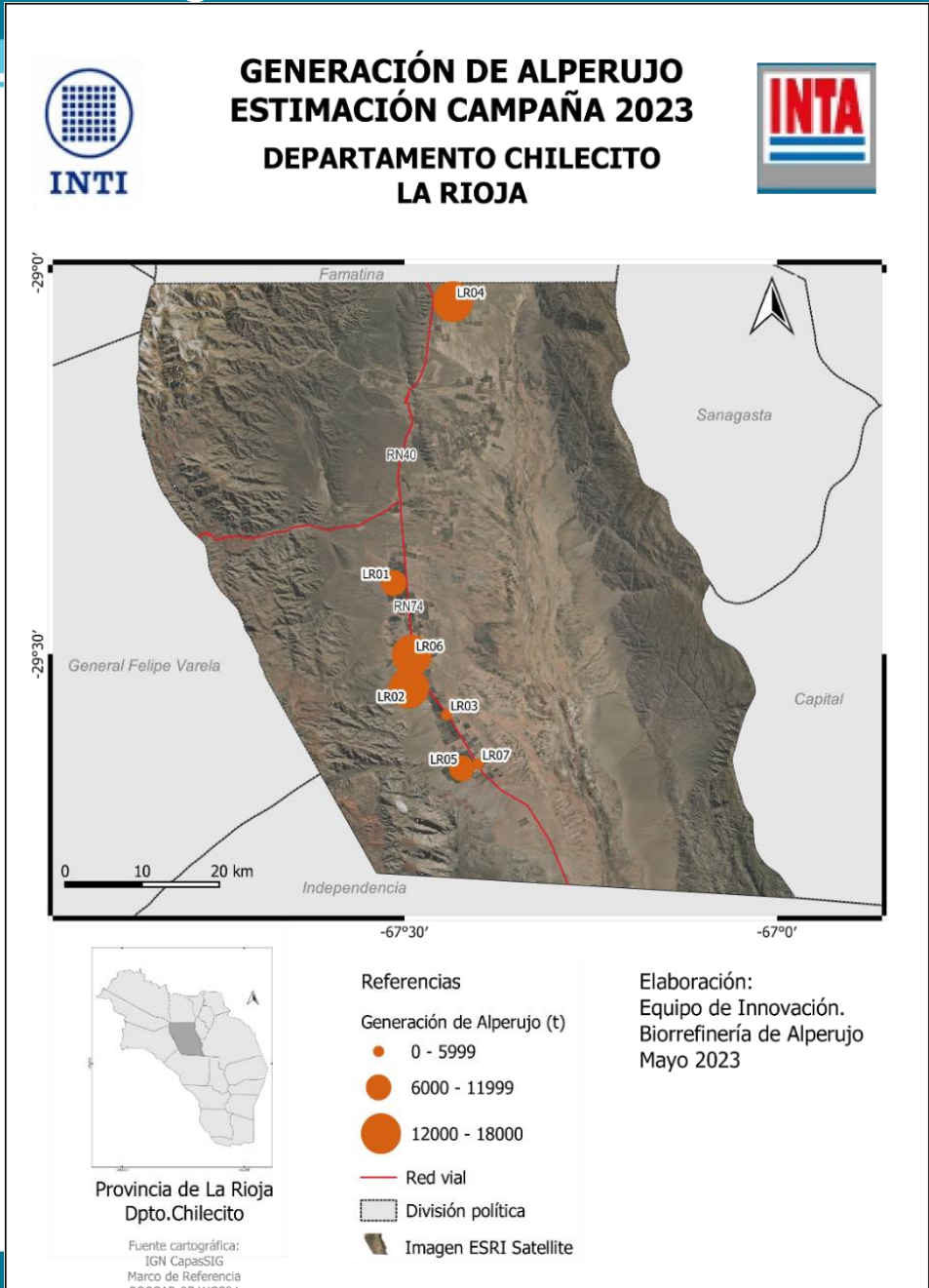
Sarmiento, SJ		
Industry code	2022 Pomace (t)	2023 Pomace (t)
SJ01	12800	16000
SJ02	2800	2800
SJ03	3040	4000
SJ04	17600	17600
SJ05	6000	8800
SJ06	4800	4800
SJ07	960	2800
SJ08	2000	4800
SJ09	1760	2400
SJ10	0	17600
SJ11	640	800
SJ12	2800	2400
SJ13	1680	1440
SJ14	720	1200
Total	**57600**	**87440**

Chilecito, LR		
Industry code	2022 Pomace (t)	2023 Pomace (t)
LR01	6400	8800
LR02	12000	12000
LR03	4800	4400
LR04	6400	12400
LR05	9600	6400
LR06	12000	12000
LR07	2800	3600
Total	**54000**	**59600**

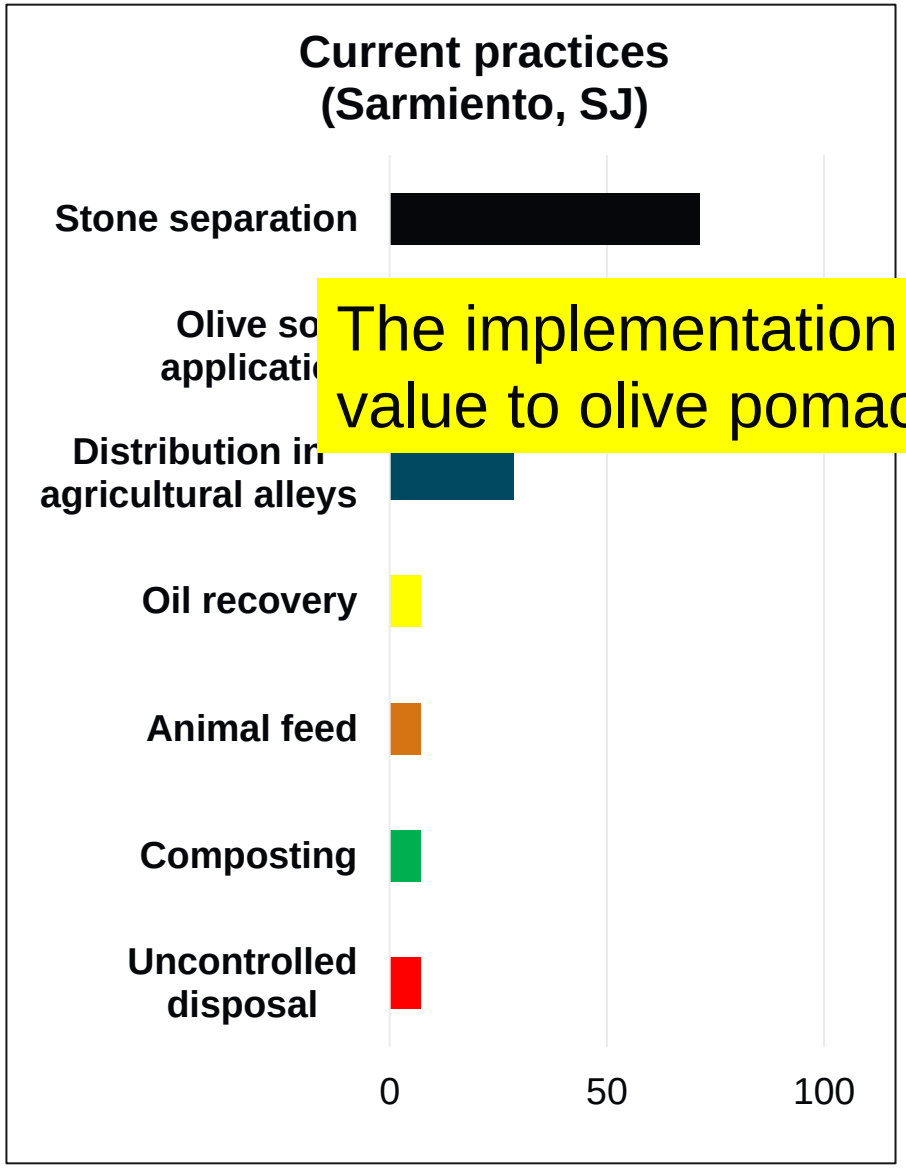
Sarmiento: 14 industries - 80.000 t
Chilecito: 7 industries - 60.000 t
Growing trend in both regions

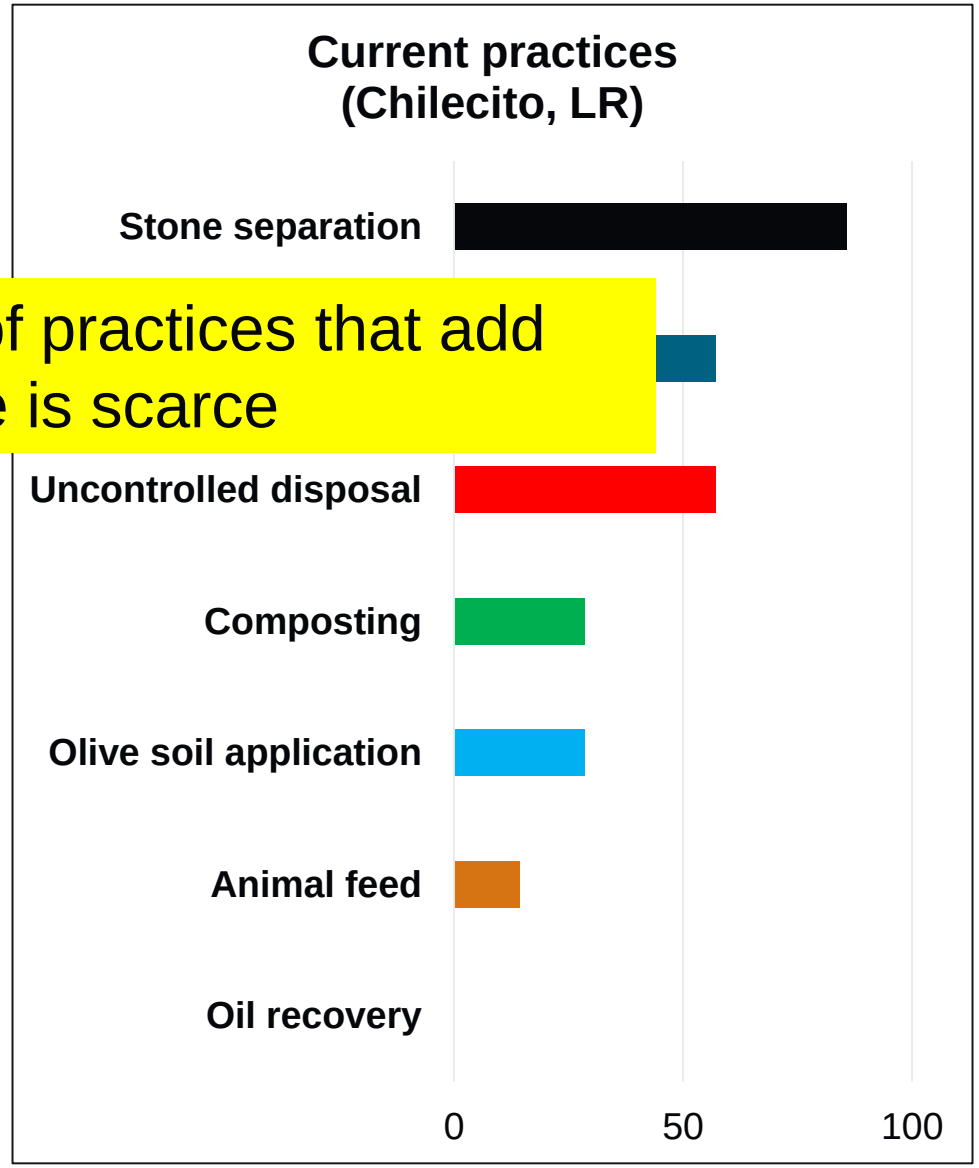
Geolocation of pomace generation





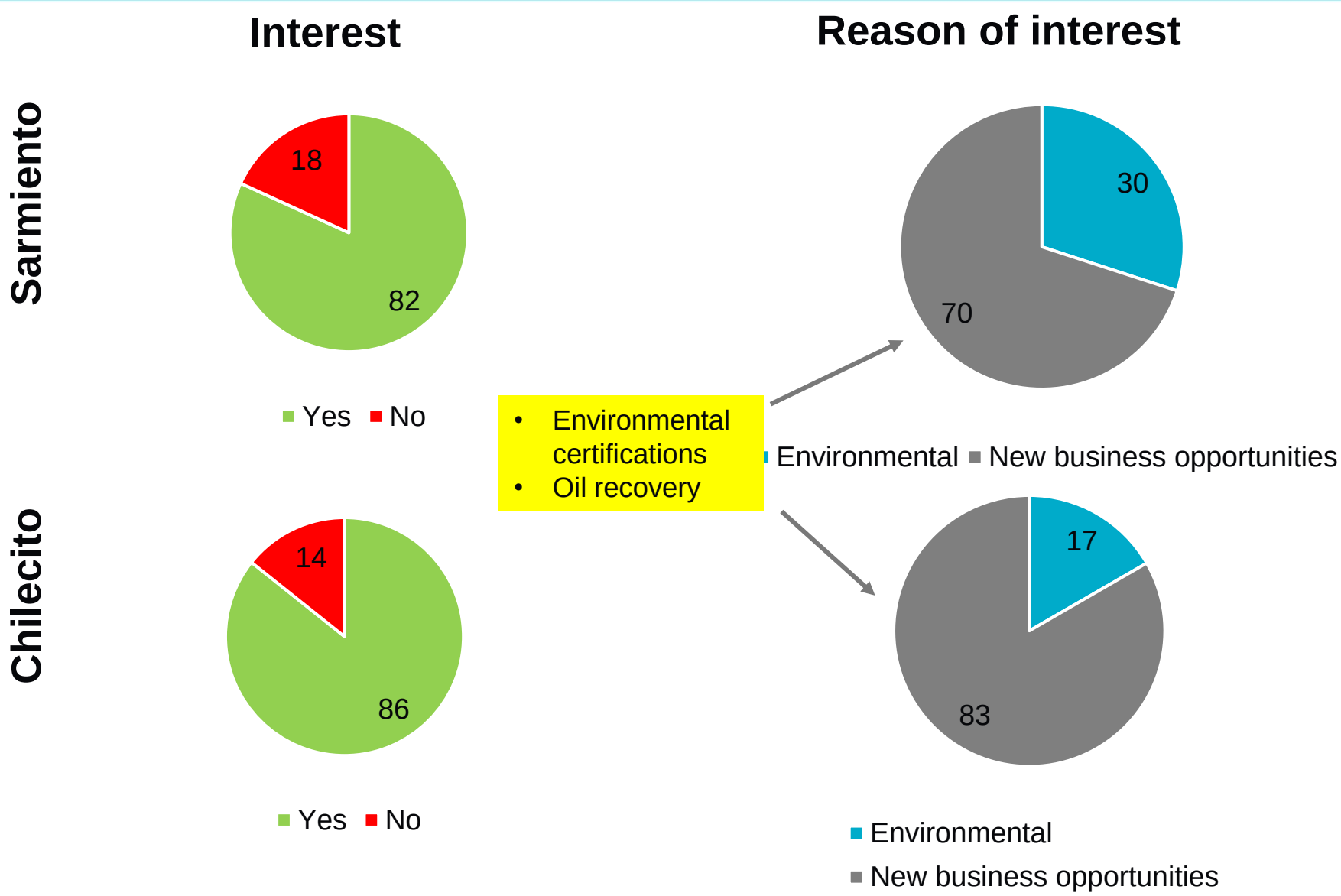
Practices currently being implemented for the management of pomace





The implementation of practices that add value to olive pomace is scarce

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.

Economic-financial viability

General assumptions and considerations for de study

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

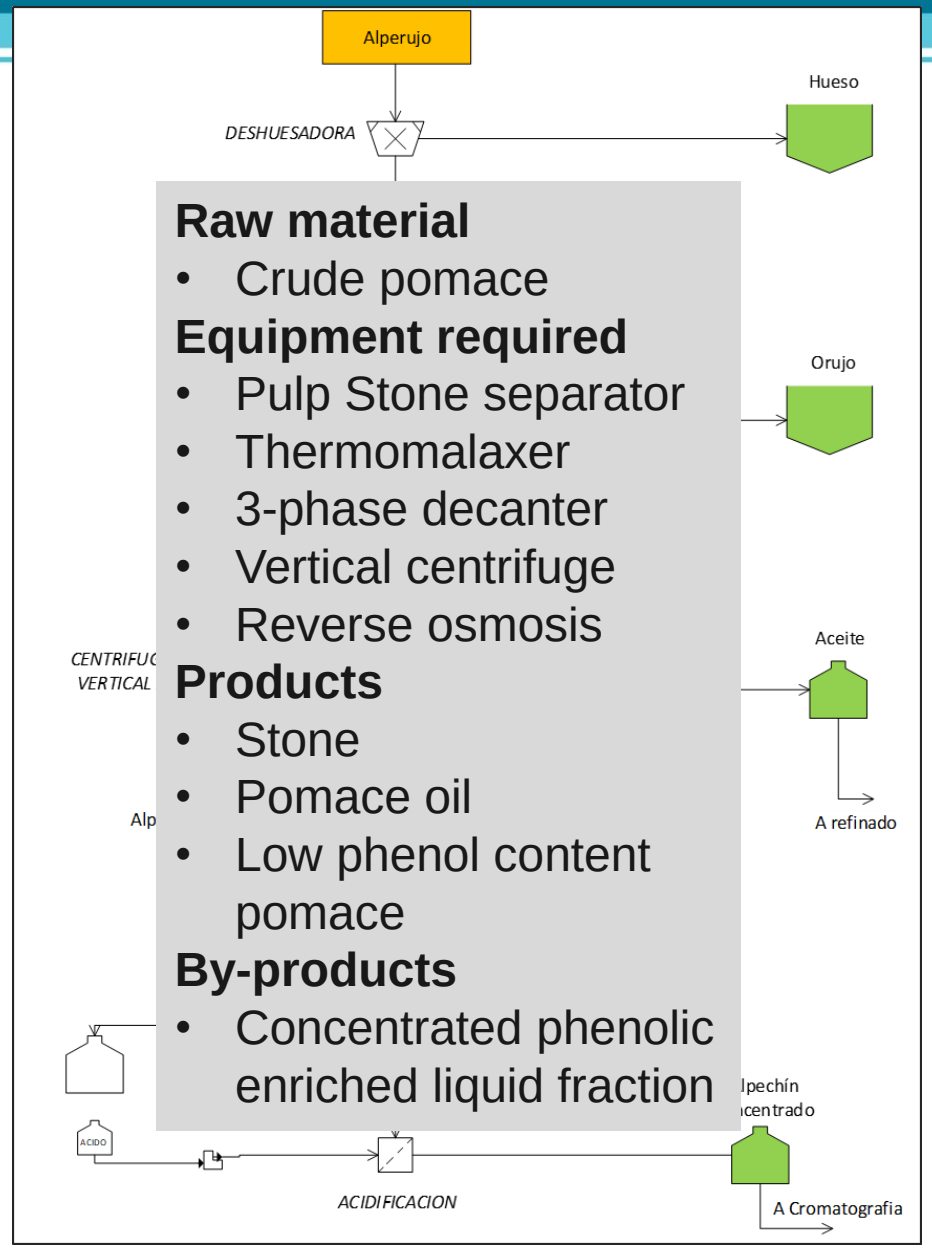
Products, use and prices considered

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”



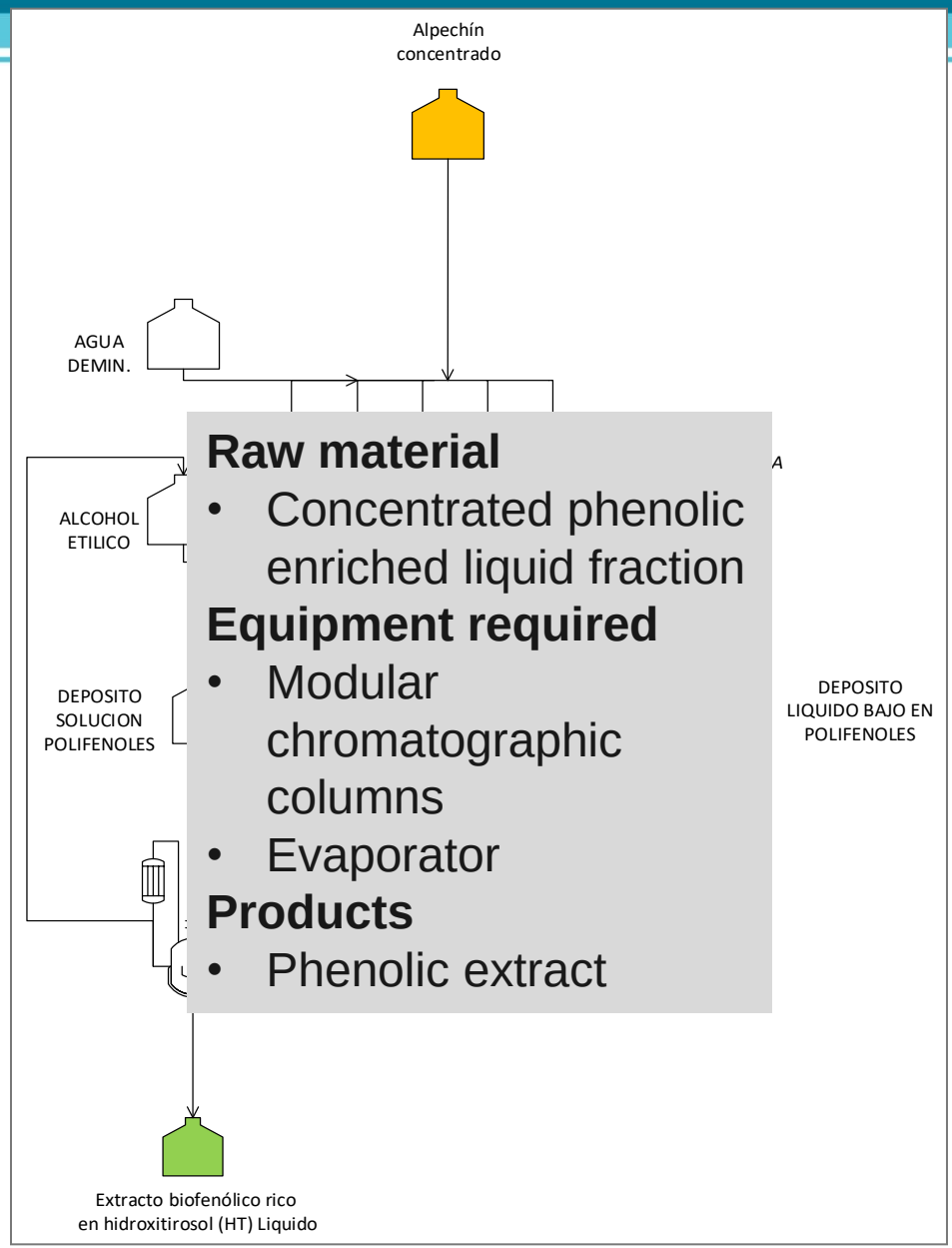
Raw material
- Crude pomace

Equipment required
- Pulp Stone separator
- Thermomalaxer
- 3-phase decanter
- Vertical centrifuge
- Reverse osmosis

Products
- Stone
- Pomace oil
- Low phenol content pomace

By-products
- Concentrated phenolic enriched liquid fraction

Process 2: “Chromatographic separation of phenols”



Raw material
- Concentrated phenolic enriched liquid fraction

Equipment required
- Modular chromatographic columns
- Evaporator

Products
- Phenolic extract

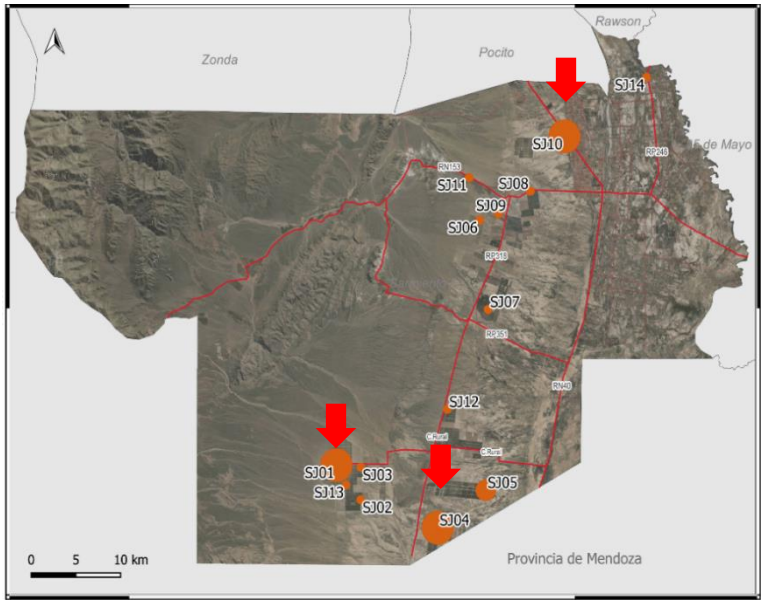
Sceneries

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

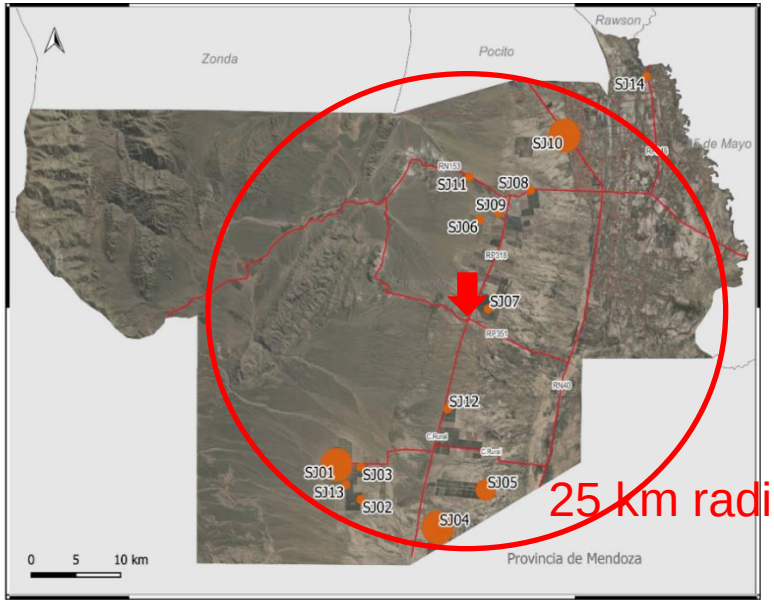
S1.2-Use of existing equipment during periods of inactivity.



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 (m^3)	**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 (m^3/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

Indicator	International olive oil price 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

Indicator	International olive oil price 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

Indicator	International olive oil price 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

Co-authors of Feasibility study:

Laura Renzi **(INTI),** Silvina Alday **(INTA),** Javier Beccaria Ibañez **(INTA)**

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

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Thanks for your attention

Muchas gracias por su atención

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