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Lab of Tomorrow 10

Insights Report

How might we use Industry 4.0 solutions to monitor and control waste and water use in Tunisian agri-food industries?

Introduction to this document

- This insights report provides a basis to enable you and your team to co-create desirable, feasible & viable business ideas in the Innovation Sprint by giving you an understanding of :

- General overview of Tunisian agri-food industries and market potentials **(Chapter 1)**
- Desktop research: facts, figures and challenges in cheese and olive oil industries in Tunisia **(Chapter 2)**
- Stakeholder research: insights on liquid waste in the cheese and olive oil industries **(Chapter 3)**
- Existing approaches limitations and Industry 4.0 promising solutions **(Chapter 4)**

- These insights put you in a strong position to solve one of the two sub-challenges of the 10th lab of tomorrow process in the Innovation Sprint :

- 1 How might we support cheese industries to monitor whey (liquid waste) parameters throughout the production process?
- 2 How might we support oil mill owners to monitor freshwater consumption & liquid waste?

CHAPTER 1

General overview of Tunisian agri-food industries and market potentials



Tunisia business market potential

Tunisia ranks among the World's top 5 of the best African countries to do Business. Source: forbes, 2019

TUNISIA 2020, LOOKING FORWARD TO ECONOMIC REVIVAL

TUNISIA 2020 - the name given to the Tunisian development strategy - is designed to reach an annual growth rate of more than 4% starting from 2020. A true society project including all the components of the nation, it defines a new vision of economic development based on highly skilled human resources and first-class infrastructure.

The legislation and the specific procedures govern the right to intellectual property. They are consolidated by the law on the protection of personal data.

Tunisia is a member of **ICSID** (the International Centre for the settlement of Investment Disputes)

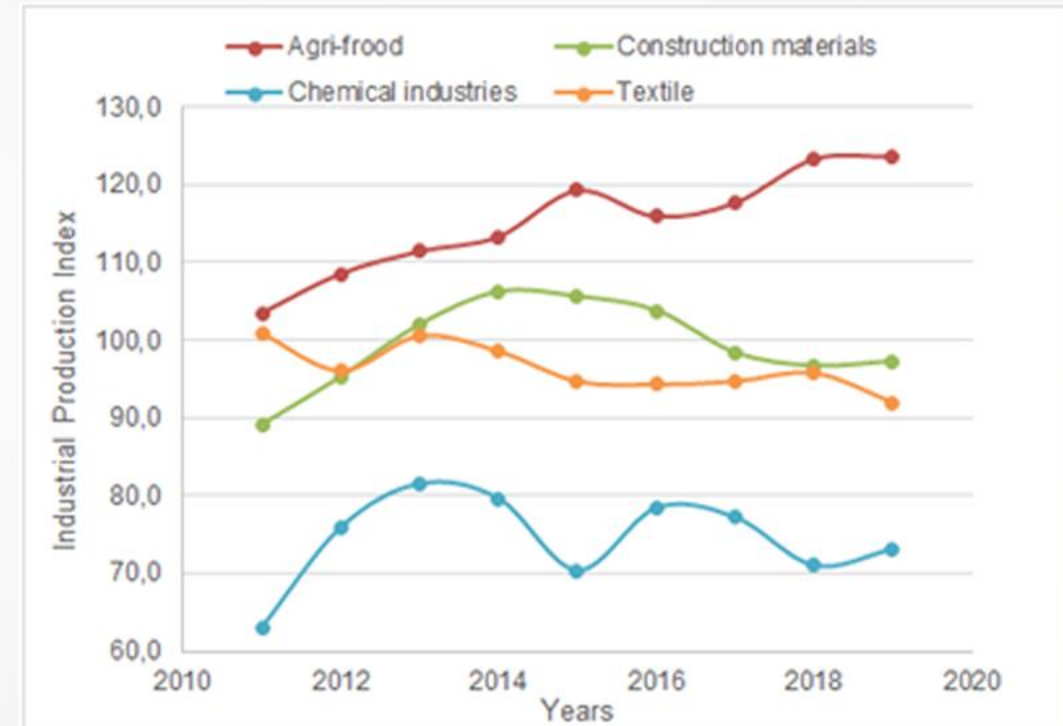
The reforms aiming at changing the investment landscape are the following :

- . Consolidation of the Banking system
- . Modernization of the Financing System
- . Regulation of the Renewable Energy Sector
- . Acceleration of Public Private Partnership (PPP)
- . Freedom of prices and competition
- . Evolution of the Regional Development Paradigm
- . Adoption of a new investment Law :
 - Governance
 - Financing
 - Incentives

Socio-economic trends of agri-food sector in Tunisia

Agri-food manufacturing is the fastest growing industrial sector in Tunisia

- The agri-food sector comprises 1,065 SMEs [1] in Tunisia
- 74 972 employees in agri-food sector (14,4% of the total employees) [2]
- Agri-food production reached an annual growth rate of 10.7% en 2020 [3]
- The industrial production index is the highest compared to the other industrial sectors (see figure), and in constant rise since 2010
- Exportation reached 3,726 MTND in 2017 [4] and is expected to rise up to 4,599 MTND in 2025 [5]



Socio-economic trends of agri-food sector in Tunisia

...but it is the most polluting (& water consuming) industry sector

- Agri-food waste, at up to 65%, makes up the largest proportion of total waste generated in the country according to the national agency of environmental protection.
- Agri-food waste is generated mainly from olive oil mills and cheese industries (in terms of margine and of cheese whey)

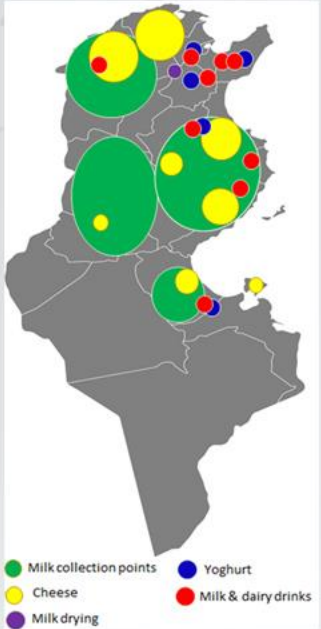


CHAPTER 2

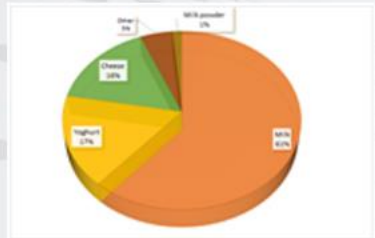
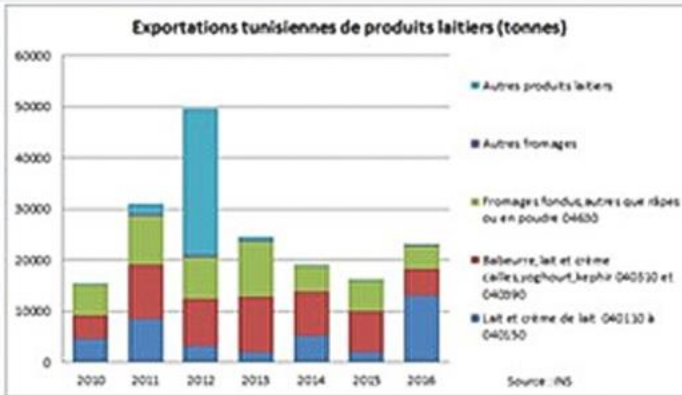
Desktop research : facts & challenges in cheese and olive oil industries in Tunisia



Industrial cheese in Tunisia

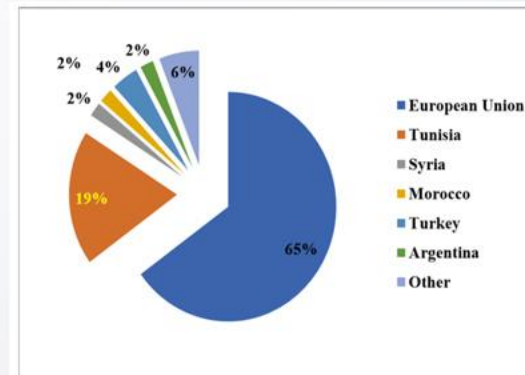


- 37 industrial units & 23 artisanal units
- Employs ~7300 people
- **Exponential development with** an annual growth average 6.11%
- Total annual turnover 1,200 million DT in 2018
- The cheese-making activity in TN uses 15 % of milk production with 145 Mi. Liters
- Cheese represents 35 % of dairy milk products destined to exportation (2018)



Olive oil industry in Tunisia

- Around 2000 olive oil mills
- 20% of the world olive area
- 80% of the Tunisian's arboriculture :
 - 2 million hectares planted olive trees
 - 100 million olive trees
- 157 thousand tons produced per year
- **Tunisia** is the third biggest exporter of olive oil worldwide after Spain and Italy. Olive oil exportation reaches 70%
- 50 million daily jobs every year (INS, 2015)



Source: ONH, 2017
 Figure 2: Distribution of Olive Oil world exports (EU/world) (2001-2016)

Main pains in the olive oil manufacturing process

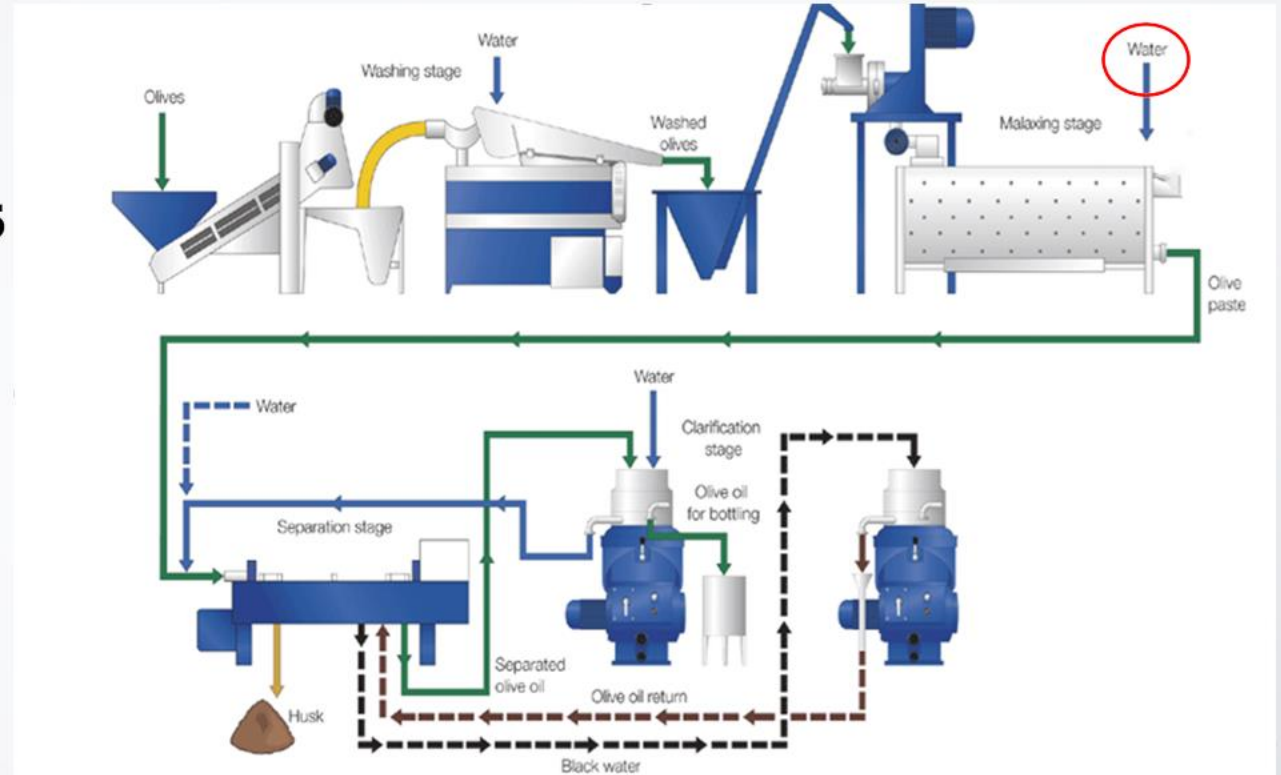
In Tunisia, there are three olive oil extractions processes :

- Traditional 5%
- [old], 3-phase decanter process 88%
- [new], 2-phase decanter process 8 %

The needed amount of water for the 3-phase method is 5 times higher than that of the 2 phase method [6]

3-phase decanter process

1. Washing
2. Milling --> Olive paste
3. Malaxating: Olive paste is malaxed for the right length of time, as judged by a skilled operator
4. Oil extracting in the decanter using water as judged by the skilled operator



***The real challenge is to add the exact water quantity that the decanter needs for an efficient extraction.**

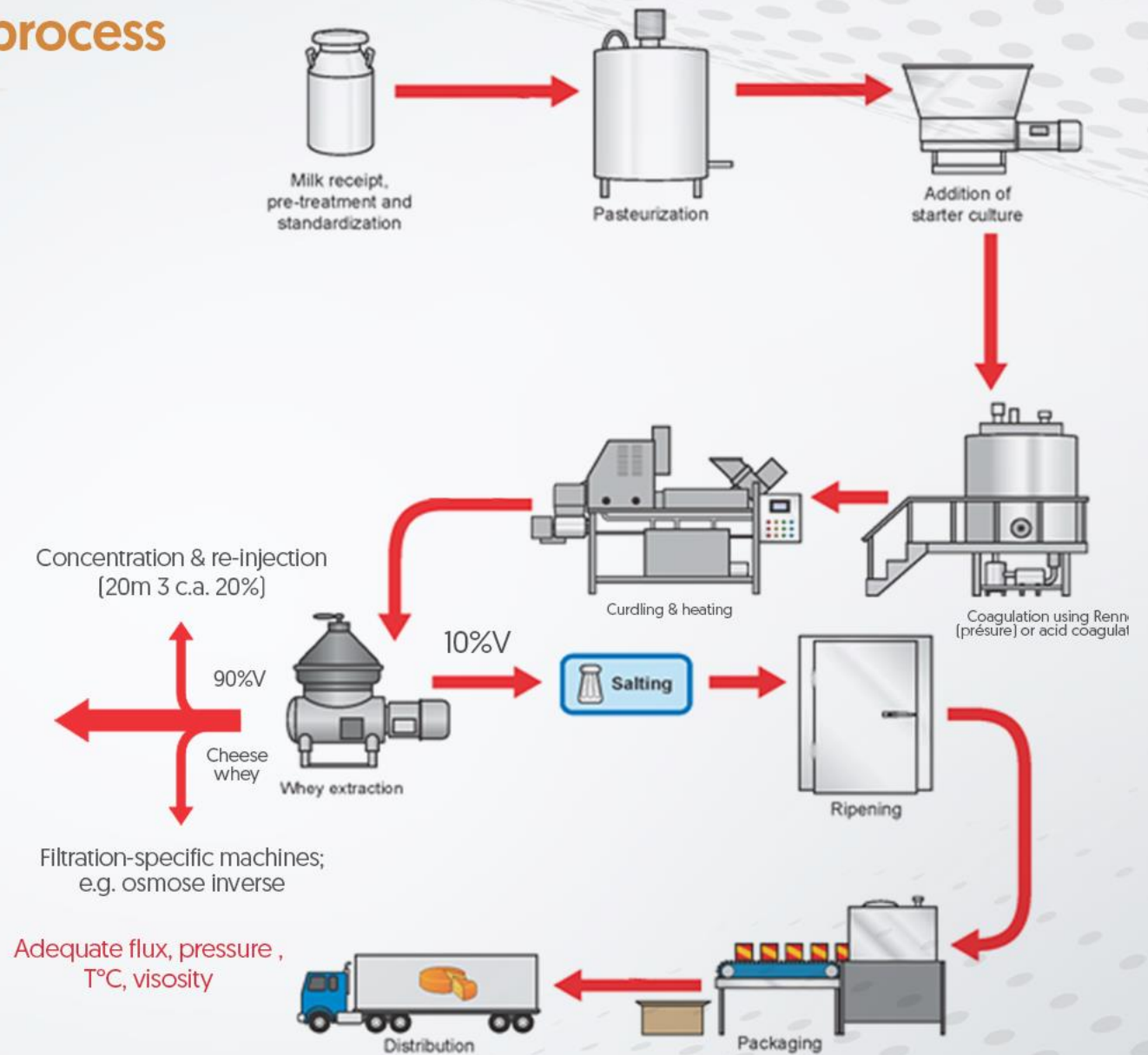
Main pains in the cheese manufacturing process

- Different industries may have vastly different production processes
- But they all need to control process variables such as temperature, pressure, viscosity, flow

- Temperature
- Liquid analysis
- Pressure
- Level
- Flow
- Humidity
- Control
- Recording
- Automation
- Monitoring

1- Water treatment plant / ONAS

Ensure a constant input of organic charge



Globally acknowledged as the most polluting food industries !

Cheese whey pollution

Cheese whey is the largest by-product of the dairy industry



For 1 Kg of cheese, 10 Kg of milk are used and 9 Kg of liquid whey are produced.



In Tunisia, the average liquid whey volume drained DAILY from one cheese production industry is **~100,000 Liters** [7]

Controlling the properties of cheese whey will result in an optimized treatment process and reduced liquid waste.

Margine (liquid olive oil residues) pollution

Adding extra-water produces extra liquid waste



Margine discharge

For 1 Tons of olives, 400 – 800 Liters of water are added in the extraction process



“every year, Tunisian oil mills produce an average of **1 million tons** of margine (olive oil wastewater) [8]

Knowing the exact required water volume will result in efficient extraction process and less liquid waste.

Cheese whey pollution impact

- Strong organic effluent: Environmental index for organic pollution BOD5 **(30,000 to 50,000 mg O₂ / L effluent)** is **30 times higher** than the standards
- Heterogenous composition: Environmental index for non-organic pollution **COD (60,000 mg O₂/L effluent)** **150 times higher** than the standards (decree NT-106-02: spill off in governmental pipelines)
- 100 x more polluting than domestic sewage ! [9]
- Cannot be treated as a normal effluent for its coggling properties!!

Margine pollution impact

- Margine is the liquid waste from the olive oil extraction process
- Margine is a viscous, acidic effluent, rich in **organic matter** and **polyphenols**
- Margine contains :
 - ✓ **1.76 mg/L- 7.47 mg/L** polyphénols Superior to the accepted ratio [0.01 mg/L norm]
 - ✓ **55.80 g/L** organic matter
- Margine is dangerous according to “Decree 2339 AN 2000 DECHET Dangereux”

Economic impact

Cheese whey

- Disruption of water treatment station & machines functioning due to high pollution load
- Heavy taxation load for diverting the by-product for treatment
- Overcharge due to pollution: 40 MDT/yr
- Cleaning fees ONAS: 10 MDT/yr

Margines

Uncontrolled fresh water consumption → Economic loss for the company

- Poor product quality: higher humidity & polyphenols concentration (marker for olive oil quality)
- Heavy taxation load for margine discharge 10 DT/m³

Economic impact

- Excessive water consumption
- Threat to aquatic environment
- Negative impact on soil crops
- Could cause human health problems in vicinity to rejection sites
- Affects the aesthetics of the natural environment

Why is it important to solve the problem ?

Desktop research raised the following issues regarding cheese and olive oil industries

Effective cheese whey monitoring :

- ✓ **Environment** : Reduce pollution
- ✓ **Economic**
 - Alleviate tax burden
 - Prevent machines & water treatment station from failure
 - Optimize cheese production process by exploiting liquid whey
 - Replace freshwater use in irrigation/cleaning by water from treated cheese whey
 - Reduce importation of cheese whey by using it instead of rejecting it.

Effective margine & freshwater monitoring :

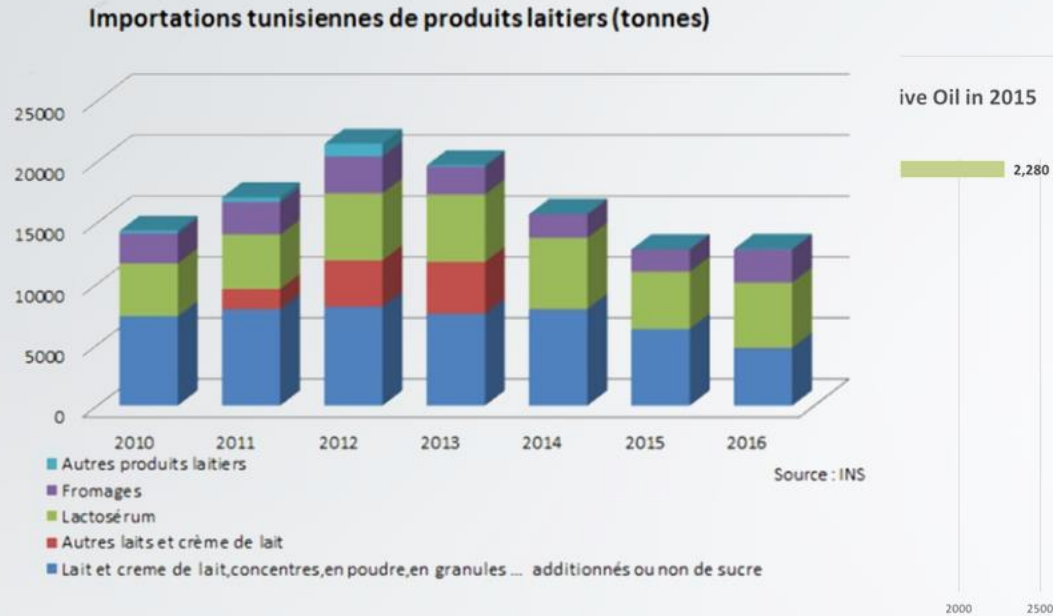
- ✓ **Environment** : Reduce pollution & freshwater consumption
- ✓ **Economic**
 - Alleviate tax burden
 - Reduce transportation and additional costs
 - Reduce water consumption in the oil extraction process
 - Optimise olive oil extraction process (reduce time and effort)
 - Better oil quality

- ✓ **Social** : Create employment for skilled labor (technicians, engineers, managers) in the field of I4.0



Economic trends in Tunisia

Importation of cheese whey

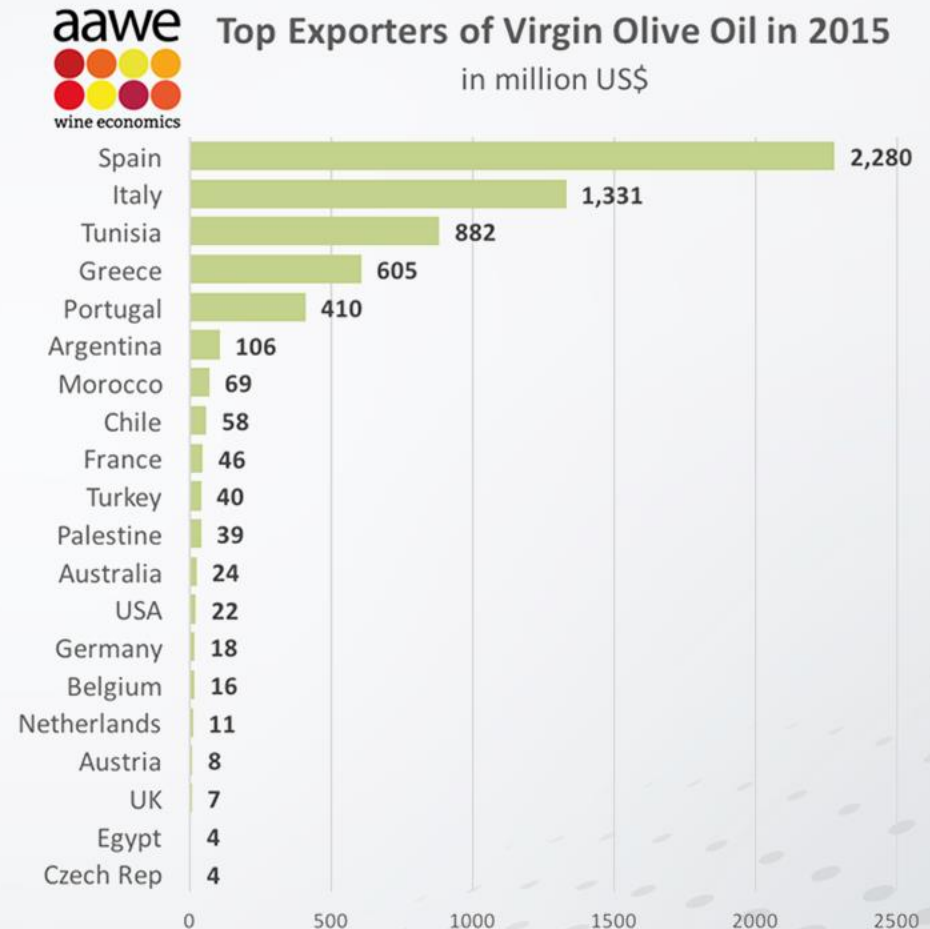


Cheese whey represents 41 % of imported dairy products (e.i. 16300 Tons) to produce infant milk, ice cream, juice, etc.₁₀.



If you can't measure it, you can't improve it!

Exportation of olive oil



CHAPTER 3

Stakeholder Research: insights on liquid waste in the cheese & olive oil industries



Who are the stakeholders in Tunisia?

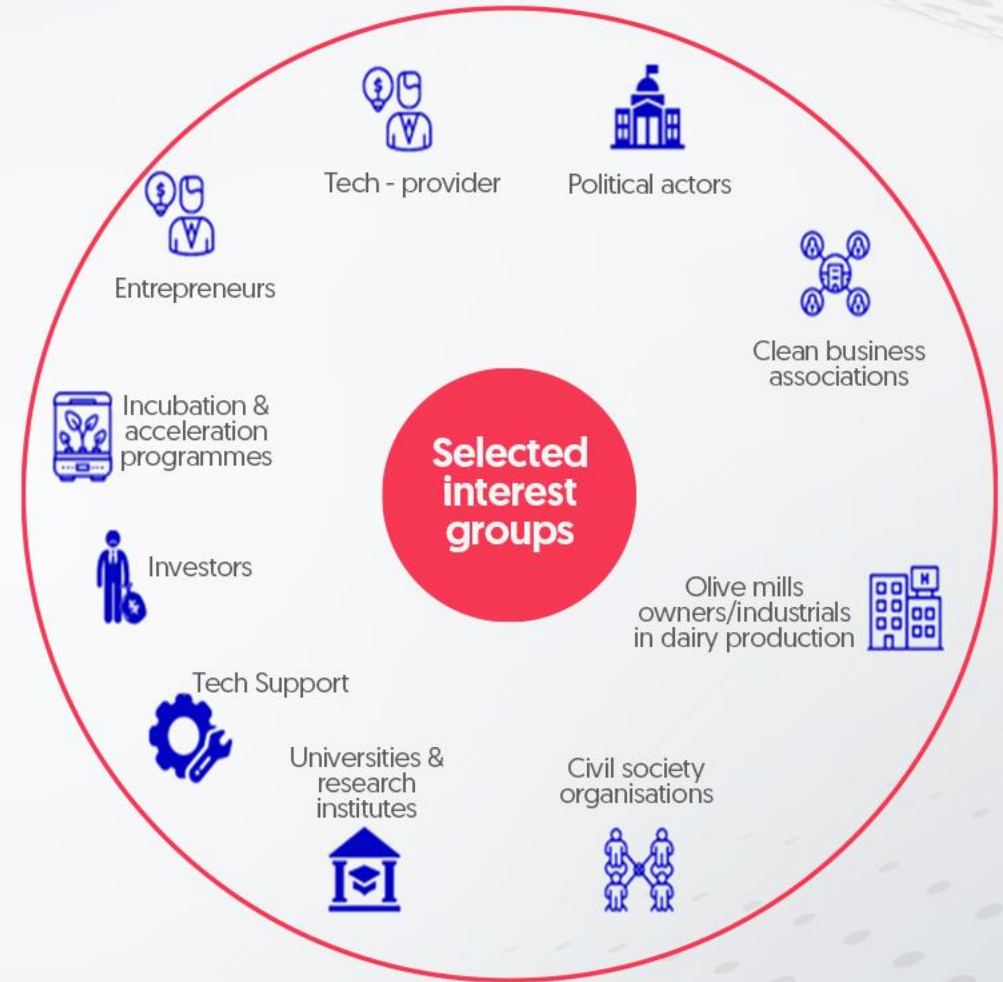
Stakeholders :

- Groups, or
- Individuals
- NGOs [wider ecosystem]
- Research institutions [wider ecosystem]

Description :

- Have the power to affect, or are affected by producing liquid waste in both olive oil and cheese industry,
- Influence legislation [governmental bodies].

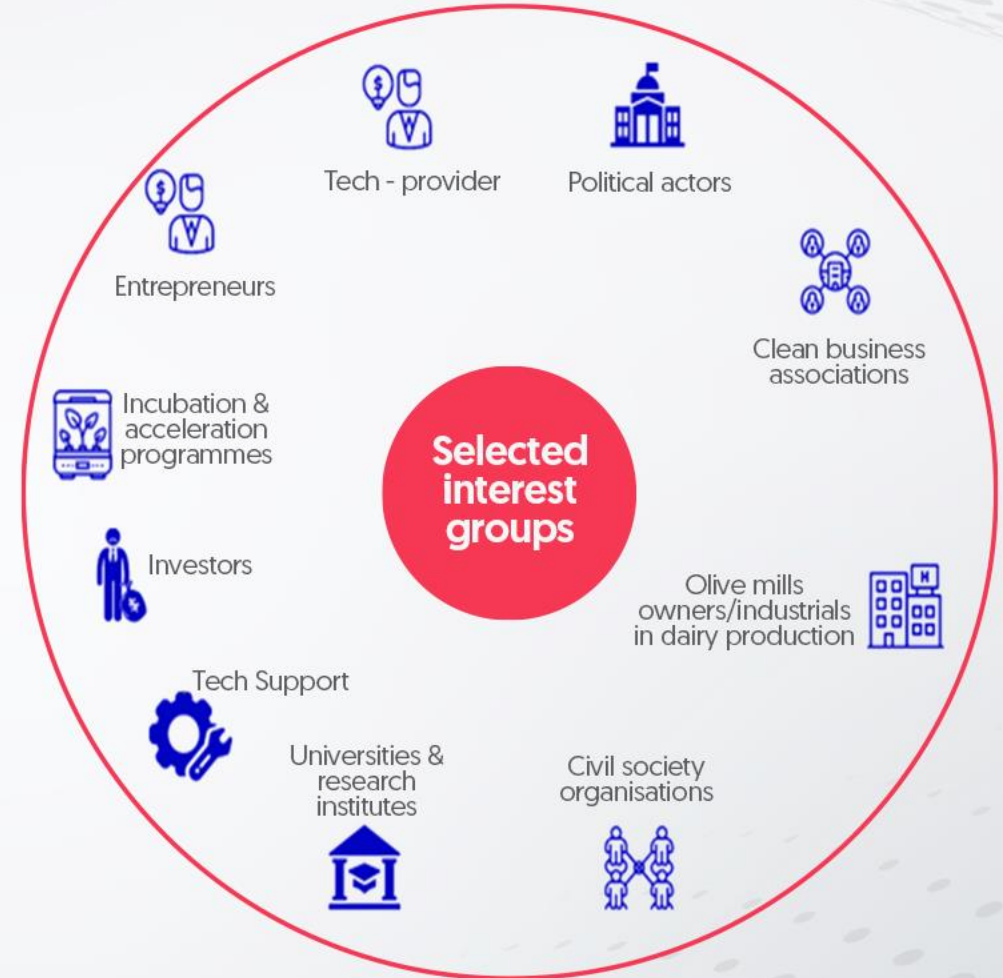
When analysing, designing business solutions in terms of services and products, it is important to have a correct understanding of stakeholders landscape as well as their behaviours, wishes and needs, in order to create sustainable business solutions that are implementable.



Who are the stakeholders in Tunisia?

People interviewed for the problem of liquid waste

- Several experts and stakeholders from different industries both in olive oil mills and cheese industry from Tunisia and Europe were interviewed via phone or at conferences, or during the field research;
- An online challenge-framing workshop was held with representatives from companies, and researchers with the finality to discuss and shape the sub-challenges;



Stakeholder research insights

The following key insights are derived from the outcome of the challenge framing workshop, during which we conducted interviews with some of the main stakeholders within the cheese and olive oil industries. We identified the 4 main categories, below :

1. *Production Process*

Usage of large quantities of water causing huge amount of liquid waste.

2. *Economic problem*

Tax burden, expensive fees, expensive production due to the high use of water

3. *Environmental problem*

Awareness towards liquid and solid water waste exists, but little is done from the industry side. Damage is caused to the land and water bodies.

4. *Regulation/Legal*

There are some regulation and legal aspects, however, they are not implemented /respected by the stakeholders.

Four key insights about liquid waste, from the stakeholders' perspective

Key Insight 1 : Production Process

Insights

Lack of efficiency in the waste management process

Knowledge and best practices are mostly human based; tacit knowledge

Low number of expert and expertise

Absence of the technology to exploit the waste; the inefficient of the existing solutions

Absence of knowledge transfer and targeted training

Lack of research and know-how in waste management

The dangerous impact of the waste on environment

Produced waste is more than the existing traditional recycling/filtering machines capacity

Production implies adding systematically water



Key Insight 2 : Economic problem

Insights

High /expensive taxes on liquid waste treatment

No clear/ interesting ROI for implementing solutions

Extra transportation, costs caused by Dumping station which are far away and in random places

High cost for liquid waste management equipment and alternative disposal



Key Insight 3: Environmental problem

Awareness towards mid- and long-term potential environmental impact is partially missing.

Insights

Pollution of the soil and water bodies

Lack of the valorisation of the liquid waste

High level of toxicity contained with in the actual liquid waste

Damages caused by the dumping into the proximity living areas



Key Insight 4: Regulation/Legal Policy

Regulation understanding and application are a major challenge slowing down innovation/solution implementation

Insights

Legal framework doesn't have a common understanding by all involved stakeholders is not the same as the reality

Legal restriction, every initiative is by default restricted until further notice

State is not managing all the waste produced by the industry neither encouraging environment Initiative.

Non explored infrastructure on the production site


No incentives for private sector waste reduction initiatives.



The Emergence of Sub-challenges

The 10th lab of tomorrow will focus on the following sub challenge vetted and voted by stakeholders and experts who participated in the Challenge Framing Workshop.

 How might we support cheese industries to monitor whey (liquid waste) parameters throughout the production process?

 How might we support oil mill owners to monitor freshwater consumption & liquid waste?

CHAPTER 4

Existing approaches limitations and I4.0 promising solutions



Existing solution approaches and their impediments

Cheese industry

✓ *Methanisation*

- Cheese whey is highly coggling substance.
Unwillingness of government to support its treatment in offsite methanisation station

✓ *Concentrators :*

- Limited technical capacity

Olive oil industry

- The water used quantity is based on human knowledge / expertise.
- This knowledge is becoming nowadays limited

Promising approaches and topics

There is not yet I4.0 solution for cheese and olive oil industries because this approach is new in Tunisia. I4.0 Centers are supporting this transition to address these challenges.

How can Industry 4.0 benefit the olive oil & cheese sectors

The integration of Industry 4.0 technologies can help cheese industrials and olive mill owners to solve many of their problems, be it to :

- Upscale the currently used machines with the lowest investment
- Improve the product traceability of the entire production process
- Enhance industrial efficiency and sustainability (clean production)



Integrate smart sensors and tracking/monitoring systems to :

Cheese challenge :

1. Real time traceability of whey parameters in the entire process (e.g. pH, temperature & viscosity).
2. Track whey cooling, rooting & user warning depending on the parameters.
3. Supervise waste effluent load parameters at the input of the water treatment plant to prevent coggling (machine failure).



Olive oil challenge :

1. Adjust machine parameters to the texture (viscosity) of the milled olive mixture.
2. Closed loop control of the water measurement to be added to the process.





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Sources and further readings

- [1] <http://www.tunisieindustrie.nat.tn/fr/zoom.asp?action=list&idsect=05>
- [2] <http://www.tunisieindustrie.nat.tn/fr/tissu.asp>
- [3] https://www.ilboursa.com/marches/la-croissance-economique-de-la-tunisie-s-etablit-a-1-en-2019_20832
- [4] <http://www.ins.tn/sites/default/files/publication/pdf/tec-2019-v11-web2.pdf>
- [5] <https://lapresse.tn/38383/secteur-agroalimentaire-maillon-fort-de-leconomie/>
- [6] <https://lapresse.tn/38383/secteur-agroalimentaire-maillon-fort-de-leconomie/>
- [7] IAT, GIVlait , Personal communications
- [8] Director of the National Waste Management Agency of Tunisia (ANGED, personal communication)
- [9] Valta et al. 2017. [10.1007/s12649-017-9862-8](https://doi.org/10.1007/s12649-017-9862-8).
- [10] H.E. Chebbi, J.-P. Pellissier, W. Khechimi, J.-P. Rolland. Rapport de synthèse sur l'agriculture en Tunisie. [Rapport de recherche] CIHEAM-IAMM. 2019, pp.99. fahal-02137636f