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Greenhouse gas assessment of olive oil in Portugal addressing the valorization of olive mill waste

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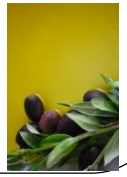


Motivation

- **Olive** cultivation and **olive oil** extraction are **important activities** in **Portugal** and other **Mediterranean** countries.

In 2013 represented **343 million euro**

Olive oil production in Portugal

Three-phase extraction

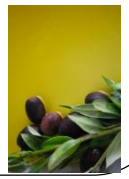
(olive oil; **pomace**; olive mill wastewaters)

Two-phase extraction

(olive oil; **wet pomace**)

can be recovered (chemical extraction, with hexane)

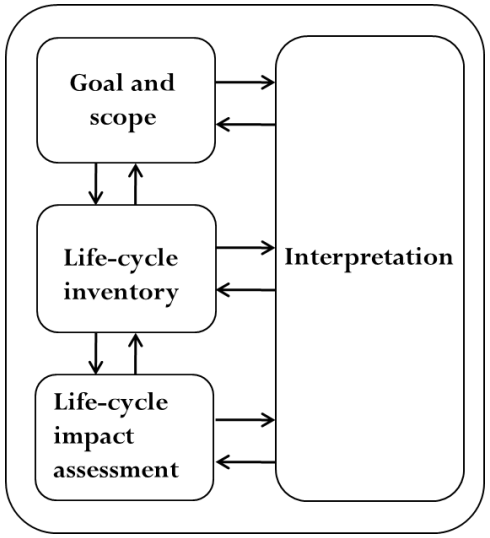
olive pomace oil and **extracted pomace**

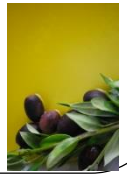


Main Objective

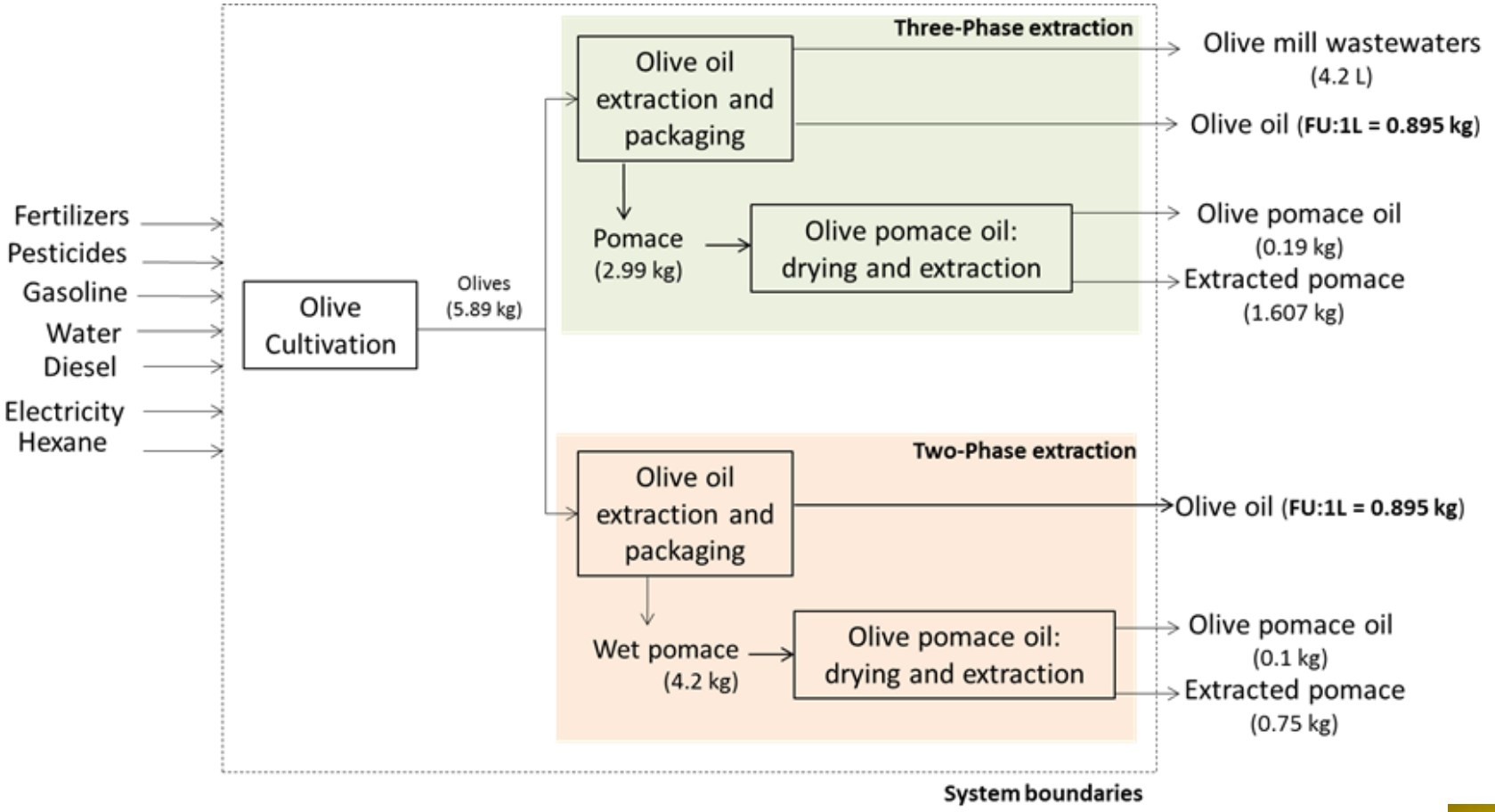
- Present a comparative a GHG life-cycle assessment (LCA) of olive oil produced from three and two-phase extraction mills, addressing the valorization of olive pomace (produced with olive oil) to produce olive pomace oil and extracted pomace

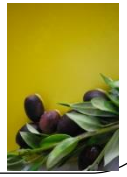
- LCA methodology





Life-cycle model

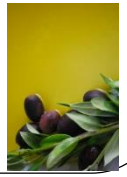




Inventory - Cultivation

Inputs		Intensive producer	Units (per ha)
Fertilizers			
	N	110	kg
	P	48.0	kg
	K	129	kg
	Urea	37.5	kg
	Borum	0.47	kg
Pesticides (a.s.)			
	Copper oxychloride	10.0	kg
	Tubeconazol	0.15	kg
	Glyphosate	2.90	kg
	Dimethoate	3.60	kg
Energy			
	Diesel	86.0	L
	Gasoline	14.0	L
	Electricity	880	kWh
Water		2000	m^3

- An intensive cultivation system
- 71% of the total olive production in Portugal in 2013
- require irrigation
- High level of fertilization and phytosanitary control
- Productivity of about 10 tonnes per hectare



Inventory – extraction

Olive oil

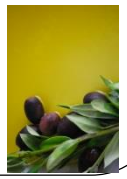
Inputs	Three-phase olive mill	Two-phase olive mill	Unit (per L)
Olives	5.89	5.89	kg
Electricity	0.269	0.269	kWh
Propane	0.01	-	kg
Water	4.82	1.24	L
Outputs			
Olive oil	1.00	1.00	L
Pomace	2.99	4.2	kg

Olive pomace oil

Inputs	Three-phase olive pomace oil mill	Two-phase olive pomace oil mill	Units (per t)
Olive pomace	16	41	t
Electricity	78	95	kWh
Diesel	20	50	L
Hexane	1.1	1.1	kg
Extracted pomace	0.6	1.85	t
Products			
Extracted pomace	8.60	7.35	t
Olive pomace oil	1	1	t

- **The efficiency** was considered **similar** from **both types of extraction**;
- **Two-phase** extraction originates **olive oil** and **wet pomace with 80% moisture** (mc wb), which hinders transportation.
- **Three-phase** extraction generate **olive oil**, **pomace (40% mc wb)** and **olive mill wastewater** (aerobic lagoons).

- **Drying of pomace** from **two-phase** mill **requires more energy**
- **Pomace** from **two-phase** mill **originates less extracted pomace** and **olive pomace**



Multifunctionality: price based allocation vs. substitution ("avoided burdens") (1)

- **<u>Olive oil production is a multifunctional process</u>**

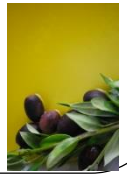
- **Price allocation:**

	Typology	Co-product	Mass quantities (kg/L $_{olive\ oil}$)	Price allocation	
				Price (€/t)	Factor
Olive oil extraction	3 phase	Olive oil	0.895	5587	98.5%
		Pomace	2.99 (b)	25	1.5%
	2 phase	Olive oil	0.895	5587	99.6%
		Wet Pomace	4.2 (c)	5	0.4%

olive oil is 220 higher than pomace

olive oil is 1100 higher than pomace

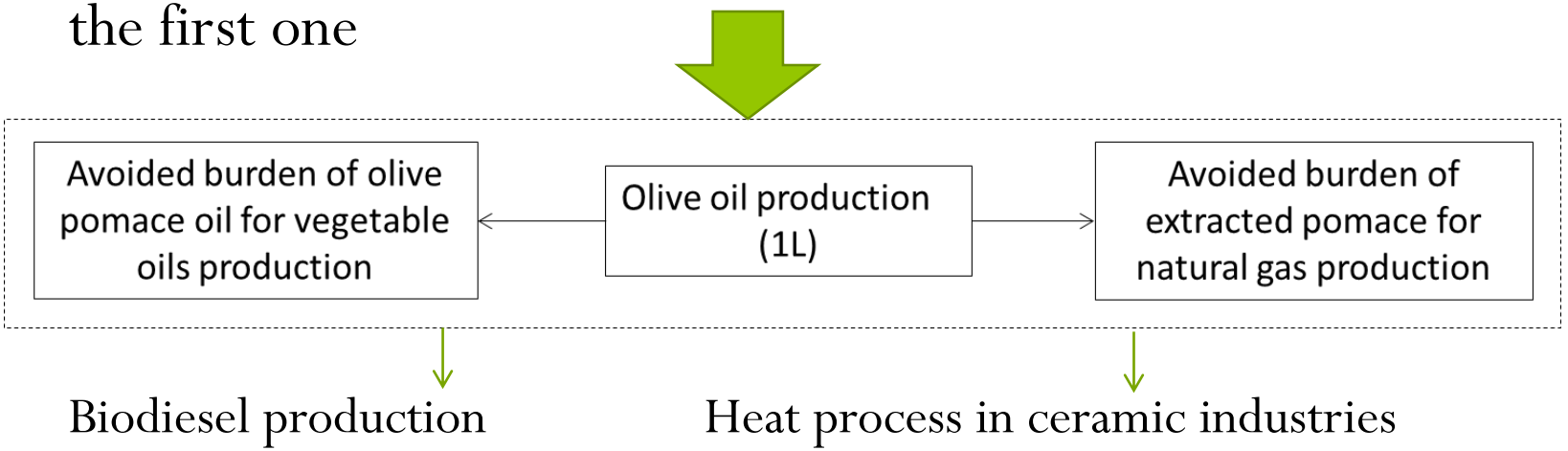
- Price allocation in olive oil production is approximately the same that allocating all impacts to olive oil



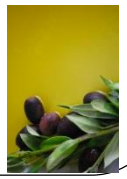
Multifunctionality: price based allocation vs. substitution ("avoided burdens") (2)

- **Substitution** considers that there is an alternative way of generating the exported functions → co-products

That are used in other system that is out of the boundaries of the first one



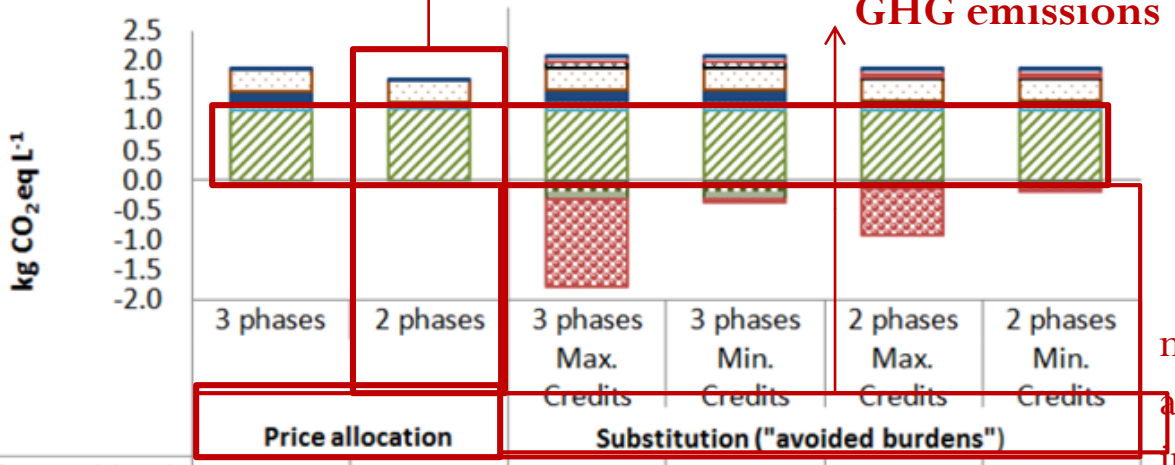
The credits for the avoided-burdens should be subtracted from the total burdens of the olive pomace oil extraction process



Results – GHG emissions

2 phase was the lower GHG emissions

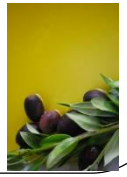
3 phase was the lower GHG emissions



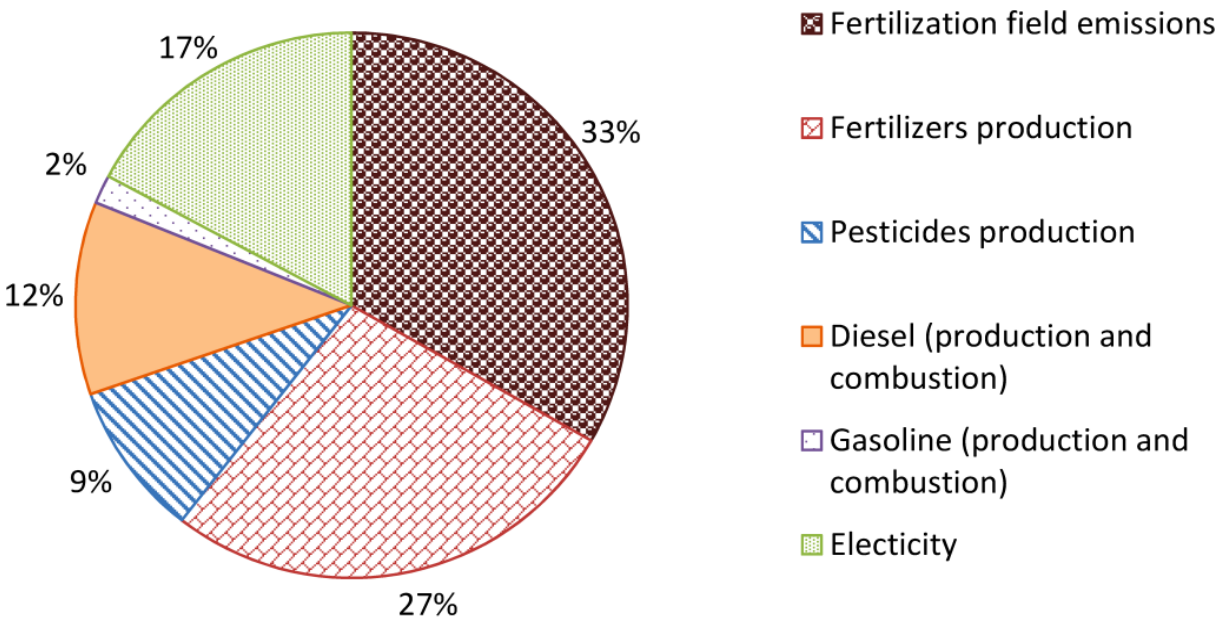
	3 phases	2 phases	3 phases Max. Credits	3 phases Min. Credits	2 phases Max. Credits	2 phases Min. Credits
Avoided production of vegetable oils			-1.48	-0.07	-0.78	-0.04
Avoided production of natural gas			-0.32		-0.15	
Transportation (olives)	0.02	0.02	0.02		0.02	
Transportation (pomace)			0.05		0.07	
Transportation (extracted pomace + olive pomace oil)			0.09		0.04	
Packing	0.36	0.36	0.36		0.36	
Olive pomace oil extraction	0.00	0.00	0.02		0.02	
Olive mill wastewater treatement	0.18	0.00	0.18		0	
Olive oil Extraction	0.14	0.13	0.14		0.13	
Cultivation	1.16	1.18	1.18		1.18	
Total (LC) GHG intensity of olive oil	**1.86**	**1.69**	**0.24**	**1.67**	**0.94**	**1.68**

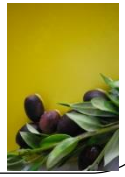
credits

multifunctionality approach influences the results and reverses the rank order of the extraction process that led to the lowest olive oil GHG intensity



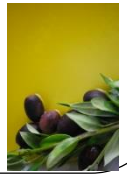
Cultivation results – Main contributors to GHG emissions





Conclusions (1)

- **Cultivation** was the life-cycle phase that **contributes more** to the **total GHG intensity** of olive oil production, **followed by packing**;
- **Multifunctionality approaches significantly influences the results** and even reverses the rank order of the extraction process that led to the lowest olive oil GHG intensity;
- **Price allocation**: olive oil from **two-phase** extraction has the **lowest GHG** emissions;
- "**Avoided burdens approach**": olive oil from **three-phase** extraction has the **lowest GHG** emissions;



Conclusions (2)

- **Results** with "**avoided burdens**" are **highly dependen**t on the **credits** associated with the **virgin oil** (there is a huge variation in the literature) displacing olive pomace oil;
- This study shows the **importance** of **olive pomace valorization** to **promote an industrial ecology system** in olive oil chain and **reduce the life-cycle GHG** intensity of **olive oil;**
- Work within the on-going project (ECODEEP) supporting this research is addressing other types of wastewater treatment systems and environmental impact categories.

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Thank you, Questions and Comments

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