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CIE CENTER FOR INDUSTRIAL ECOLOGY

UNIVERSIDADE DE COIMBRA

LIFE-CYCLE GREENHOUSE GAS ASSESSMENT OF PORTUGUESE CHESTNUT

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OUTLINE

1. Introduction
   i. Motivation
   ii. Aim
2. Methods
   i. Life-cycle model
   ii. Life-cycle inventory
3. Results
   i. Cultivation
   ii. Processing
4. Conclusions

1. INTRODUCTION

Motivation:

- Portugal was the third largest producer of chestnut in Europe (EU 28) and the seventh worldwide in 2013:
  - annual production of 24.7 thousand tons;
  - orchard area of 35 thousand hectares.
- The north of the country is the main production region (84% of production and 88% of the orchard area).
- It's one of the few fruits with a positive trade balance, having contributed to about 41 million € in 2013.

(INE, 2014; FAO, 2015)

Life Cycle Assessment (LCA) quantifies the potential life-cycle environmental impacts and identifies opportunities for improvement, however:

- There are no LCA articles regarding chestnuts.

Aim:

→To assess the GHG intensity of Portuguese chestnut.

2. METHODS

Life-cycle model:

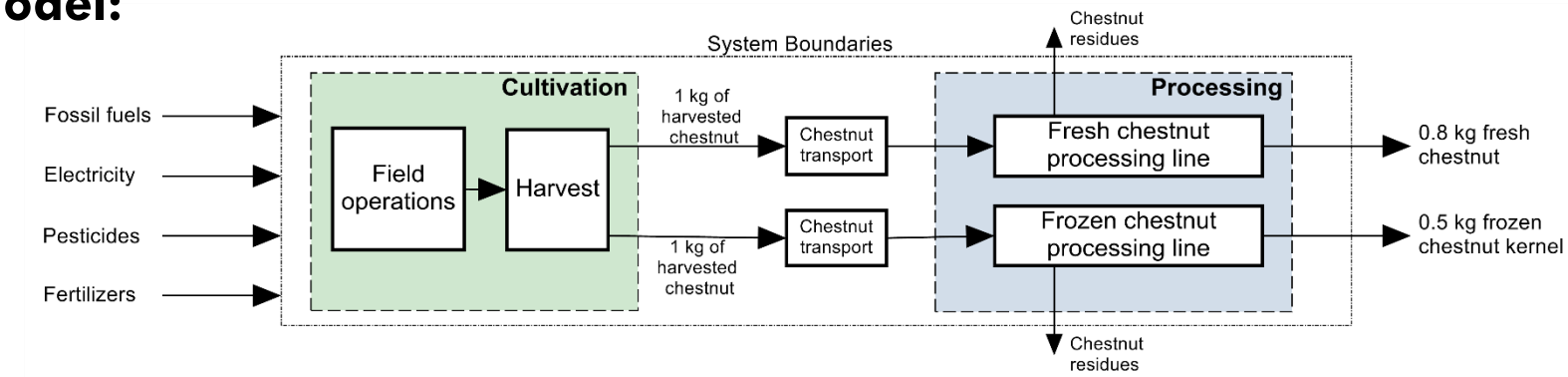


Figure 1 – Chestnut production system.

F.U.: 1 kg harvested chestnut

Three cultivation systems in northern Portugal.

Processing factory: fresh and frozen chestnut production lines.

2. METHODS

Life-cycle inventory: cultivation

Table 1 – Main characteristics of the studied producers.

Producer	P1	P2			P3	
	2011	2010	2011	2012	2010	2011
Area (ha)	92	7			10	
Production (ton)	81	9	6	8	2	4
Productivity (kg/ha)	881	1214	786	1143	228	396

Table 2 – Main inputs of chestnut cultivation, per hectare.

Producer	P1	P2	P3
Fertilizers (kg):			
N	9.0	15.0	19.8
N organic	9.8	-	0.03
P	38.6	31.7	29.7
P organic	3.0	-	0.03
K	18.0	30.0	29.7
K organic	7.6	-	0.03
$CaCO_3$	348.6	-	520.0
Pesticides[1] (kg):			
Copper oxychloride	12.5	-	4.9
Fosetyl-aluminium	-	-	7.4
Energy (L)			
Diesel	101.1*	42.9	71.3
Petrol	1.6	-	-
Transport (km):	*Included in total diesel	20.0 (lorry)	2.0 (tractor and trailer)

1) The amount of pesticides is shown as a function of its active ingredient.

- Main agricultural processes:
  - soil management,
  - fertilization,
  - pruning,
  - pesticide treatments and
  - harvesting.

- Chestnut tree in full production (except for 80% of P3 orchard area).

- Emissions accounted for:
  - fertilization (direct and indirect N_2O emissions and CO_2 from liming),
  - agricultural inputs production,
  - combustion of petrol and diesel in agricultural operations,
  - chestnut transportation to the factory.

2. METHODS

Life-cycle inventory: processing

Table 3 – Main inputs of chestnut processing.

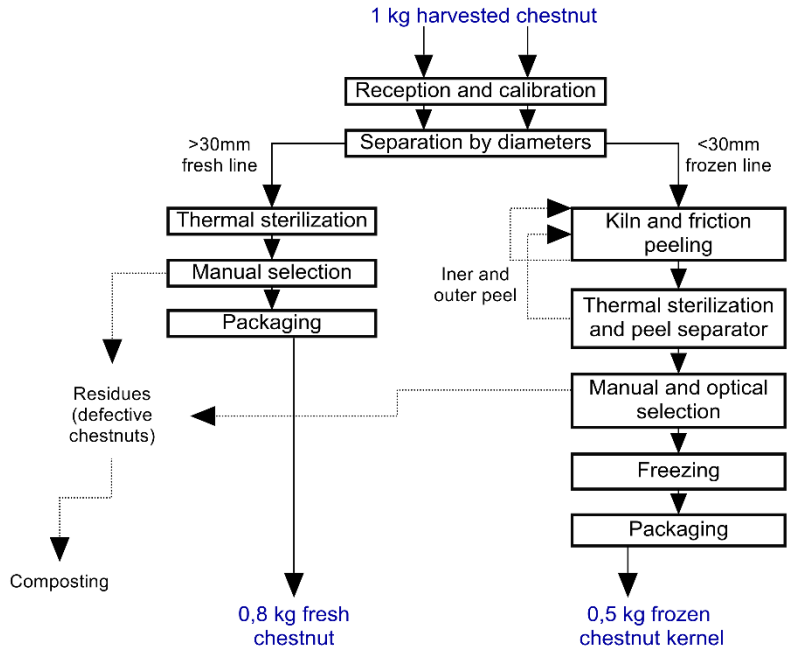
Inputs	Production line		Unit / kg $_{harvested\ chestnut}$
	Fresh chestnut	Frozen chestnut	
Electricity	0.05	0.49	kWh
Propane	19.02	25.83	g

used mostly for cold production.

used in kilns and steam generators.

- Emissions accounted for:
  - production and combustion of propane
  - generation of electricity

Figure 2 – Chestnut processing system.



Losses from chestnut processing:

frozen chestnut

- chestnut selection
- peeling
- water loss

fresh chestnut

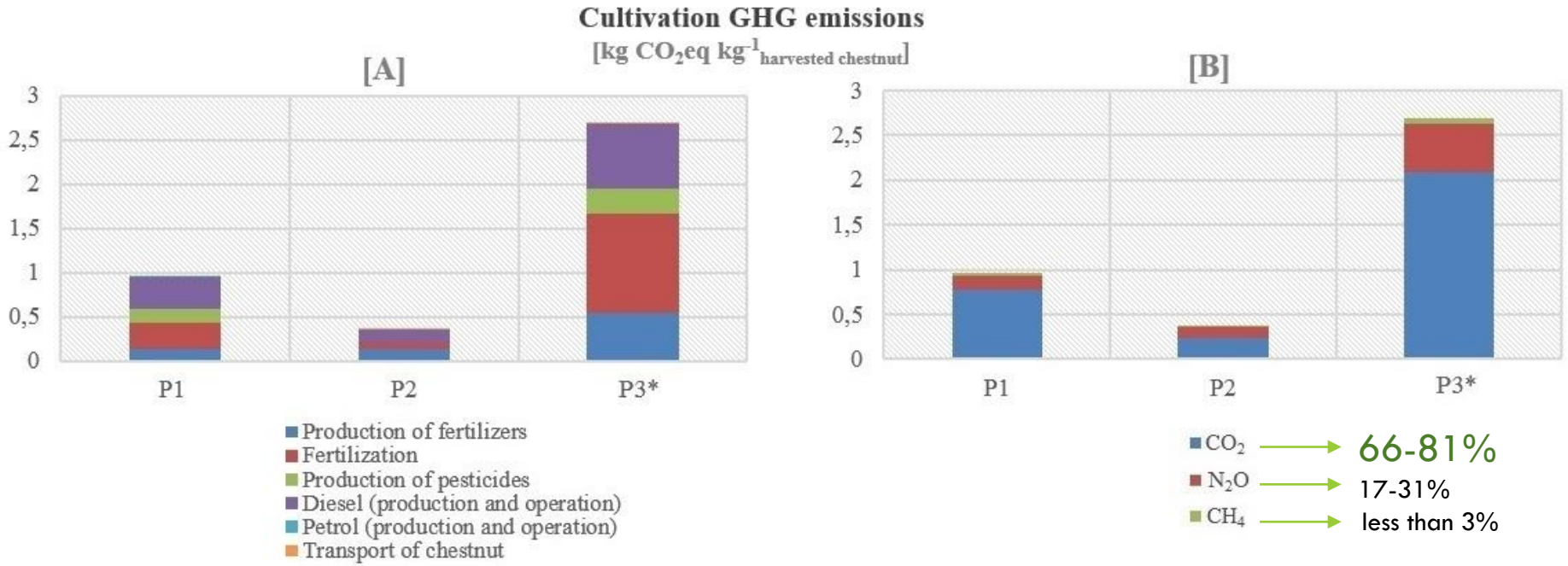
- chestnut selection

3. RESULTS

Figure 3 - [A] GHG emissions from chestnut cultivation. [B] Contribution of GHG type to cultivation emissions.
* Only 20% of P3 area was in full production.

Cultivation:

Yearly weighted averages, according to chestnut production



Production and application of fertilizers: 45-62%
Emissions from diesel requirements were most relevant for P1: 39%

CO_2 emissions from P1 and P2: diesel production and operation (46% and 53%); P3: liming (35%)

GHG emissions from cultivation ranged between **0.36** (P2) and **2.69** kg CO_2eq kg^{-1} harvested chestnut (P3).

3. RESULTS

Processing:

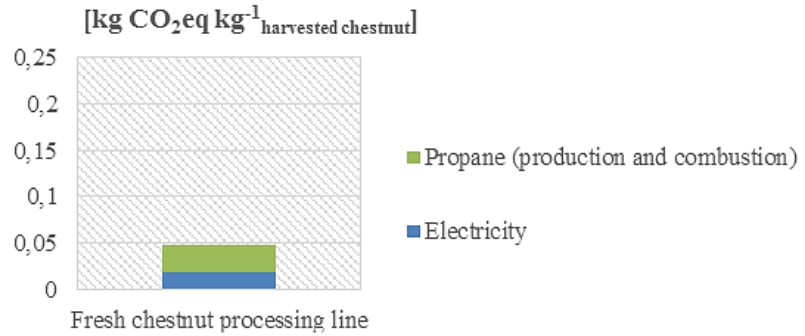


Figure 4 – GHG emissions of fresh chestnut processing.

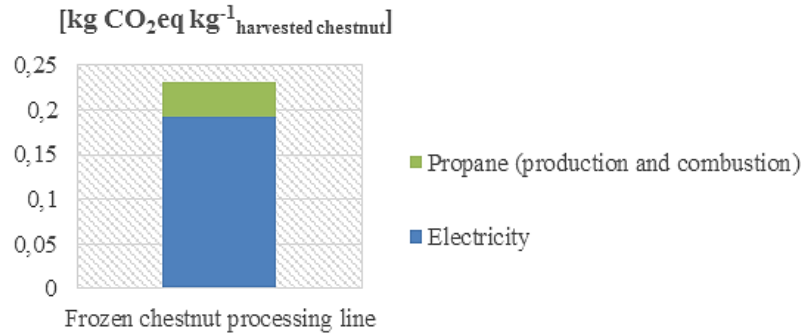


Figure 5 – GHG emissions of frozen chestnut processing.

Fresh chestnut processing:
→ **0.05** kg CO_2eq kg^{-1}harvested chestnut
Propane production and combustion (61%).

×4.6

Frozen chestnut processing:
→ **0.23** kg CO_2eq kg^{-1}harvested chestnut
Electricity generation (83%).

4. CONCLUSIONS

- GHG emissions from cultivation
  - → fertilizer production and application (45-62%).
- Processing GHG emissions
  - → fresh line: propane (61%); frozen line: electricity (83%).

- **The overall GHG intensity ranged between 0.41-2.74 (fresh) and 0.60-2.92 (frozen) kg $CO_2eq\ kg^{-1}_{harvested\ chestnut}$, cultivation representing 60-98% of impacts.**

- The results of this study demonstrate the importance of resource management practices at the cultivation stage, namely an efficient use of fertilizers and fossil fuels.

ONGOING/FUTURE WORK

A cradle to plate analysis comparing fresh and frozen chestnut, including:

- Cultivation
- Processing and packaging
- Distribution
  - national and exports
  - comparison of various means of transport
  - inclusion of refrigeration requirements
- Retail operations
- Household
  - storage
  - preparation
  - consumption

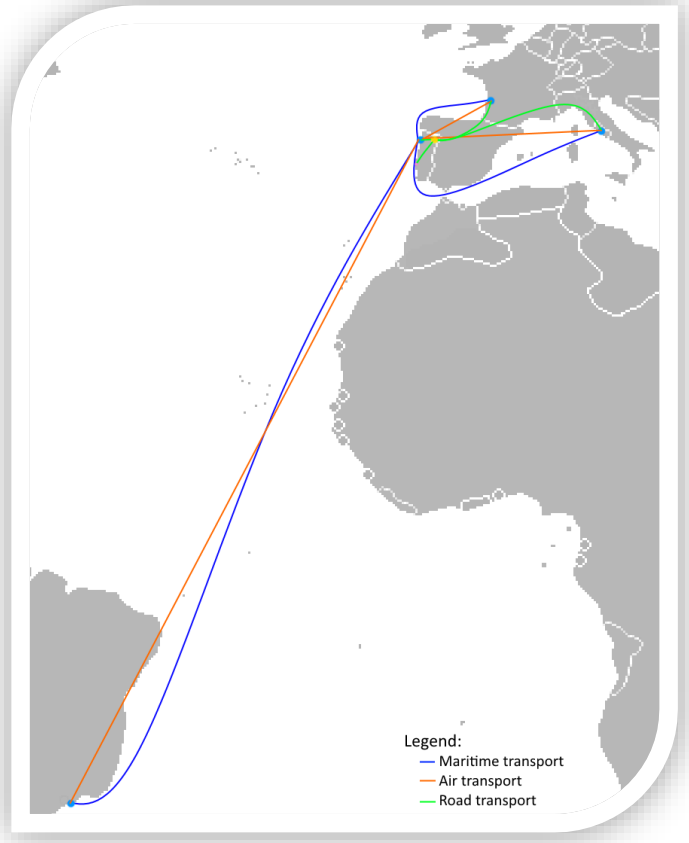


Figure 6 - Graphical representation of distribution scenarios analysed.

Assessment of other impact categories, in addition to climate change:

- Terrestrial acidification, freshwater eutrophication, and marine eutrophication

and

- Total primary energy consumption

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QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007-2013
COMPETE PROGRAMA OPERACIONAL FACTORES DE COMPETITIVIDADE
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional
FCT Fundação para a Ciência e a Tecnologia