cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

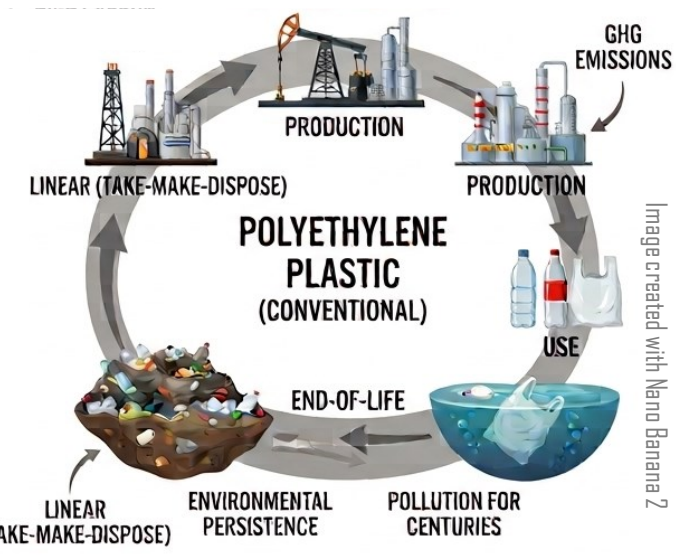
EFFECT OF GLYCEROL CONTENT ON ENVIRONMENTAL IMPACTS OF BIODEGRADABLE PECTIN PLASTICS

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INTRODUCTION

CURRENT SCENARIO



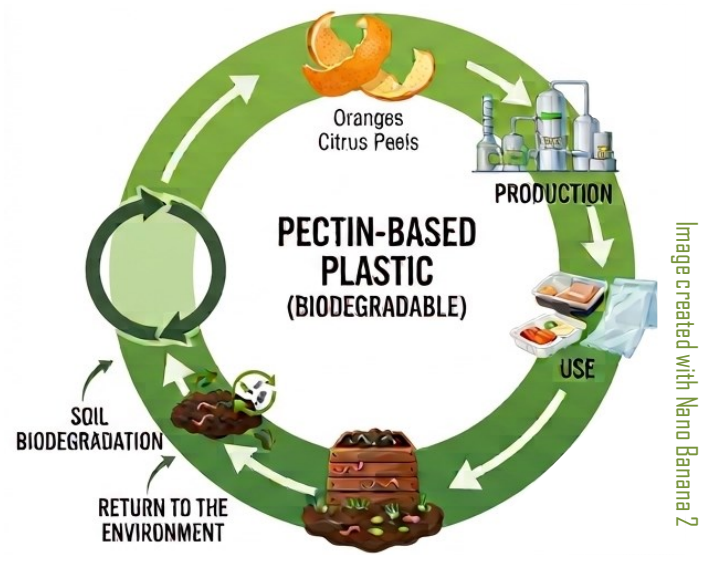
Technological transition

CENTRAL QUESTIONS

- ✓ Is pectin eco-friendlier than polyethylene?
- ✓ How does glycerol affect the eco-performance of pectin-based plastics?

LIFE CYCLE ASSESSMENT

PROPOSED SCENARIO



OBJECTIVES

Evaluation of environmental impacts of the production of PEC-based plastics loaded with glycerol (0 – 30 wt.%), considering damage to ecosystems, human health, and natural resources as recommended by ISO 14040 [1]. To compare the impact indicators of a 30 wt.%-loaded PEC plastic with those of a fossil-based low-density polyethylene (LDPE) plastics.

MATERIALS AND METHODS

GOAL AND SCOPE DEFINITION

Product model: plastic packaging – 11.7 g.

System boundary: cradle-to-grave (open dump for LDPE; Industrial composting for pectin.

LIFE CYCLE INVENTORY

Pectin extraction from orange peels [2,3].

Fossil-based LDPE and soybean-derived glycerol datasets from database Ecoinvent 3.7.2.

LIFE CYCLE IMPACT ASSESSMENT

Impact indicators were calculated using the ReCiPe Midpoint (H) (2016) method.

Uncertainty calculation by Monte Carlo Simulation.

RESULTS AND DISCUSSION

Table 1 – Cradle-to-grave impact results of biodegradable PEC plastics comprising different glycerol contents (FU = 1 unit of plastic packaging)

Impact indicators*	Glycerol content (wt.%)		
	10	20	30
GWP (kg CO_2 eq)	0.056 ± 0.014	0.057 ± 0.013	0.058 ± 0.012
FWE (kg 1,4-DCB) × 10^{-3}	2.01 ± 0.66	1.87 ± 0.62	1.77 ± 0.59
TA (kg SO_2 eq) × 10^{-4}	5.37 ± 1.77	4.82 ± 1.58	4.43 ± 1.54
FWET (kg P eq) × 10^{-5}	1.53 ± 0.58	1.60 ± 0.53	1.71 ± 0.54
HT-NC (kg 1,4-DCB)	0.023 ± 0.011	0.026 ± 0.010	0.028 ± 0.010
HT-C (kg 1,4-DCB) × 10^{-3}	2.99 ± 1.42	2.91 ± 1.60	2.89 ± 1.50
FPMF (kg $PM_{2.5}$ eq) × 10^{-4}	1.31 ± 0.34	1.25 ± 0.31	1.22 ± 0.30
FRS (kg oil eq) × 10^{-2}	1.03 ± 0.25	0.94 ± 0.22	0.89 ± 0.20
WC (m^3) × 10^{-3}	5.52 ± 26.57	5.52 ± 24.15	5.00 ± 19.73
LU (m^2a crop eq)	0.061 ± 0.019	0.064 ± 0.017	0.068 ± 0.017

*GWP – Global warming potential; FEW – Freshwater ecotoxicity; TA - Terrestrial acidification; FWET – Freshwater eutrophication; ME – Marine eutrophication; HT – Human toxicity; FPMF – Fine particulate matter formation; FRS – Fossil resource scarcity; WC – Water consumption; LU – Land use.

LDPE vs Pectin

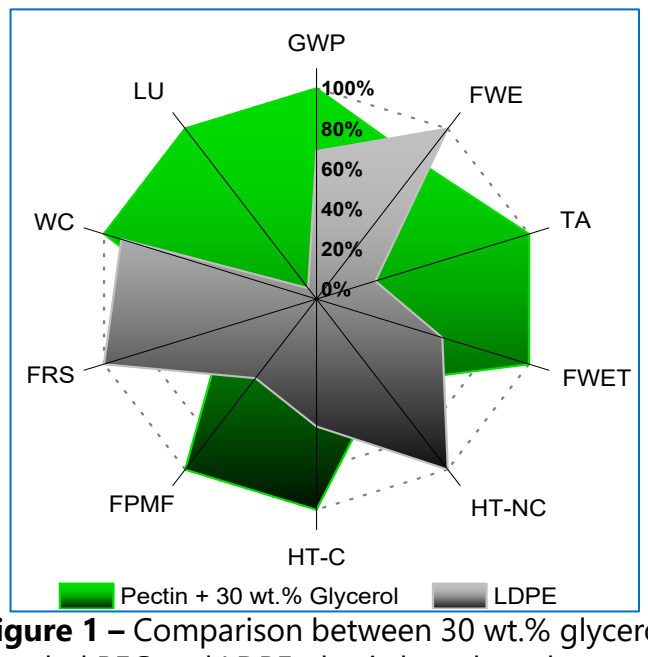


Figure 1 – Comparison between 30 wt.% glycerol-loaded PEC and LDPE plastic bag though several environmental categories.

CONCLUSIONS

Pectin-based plastics represent a promising alternative to LDPE in terms of resource renewability, but their environmental performance is highly context-dependent and requires optimization to compete effectively across all impact categories. Upstream processes, particularly PEC extraction and glycerol sourcing, are likely to be the main environmental hotspots, so their improvement may yield more significant environmental benefits towards implementing pectin as a sustainable packaging material.

REFERENCES

[1] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Environmental Management — Life Cycle Assessment — Requirements and Guidelines. ISO 14044:2006(E). 2006

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[3] GARCIA-GARCIA, G. et al. Life-Cycle Assessment of Microwave-Assisted Pectin Extraction at Pilot Scale. *ACS Sustainable Chemistry & Engineering*, v. 7, p. 5167–5175, 2019.

ACKOWLEDGMENTS

DEMa UFSCar
CNPq
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