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Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Production and Life cycle assessment of microbial colorants

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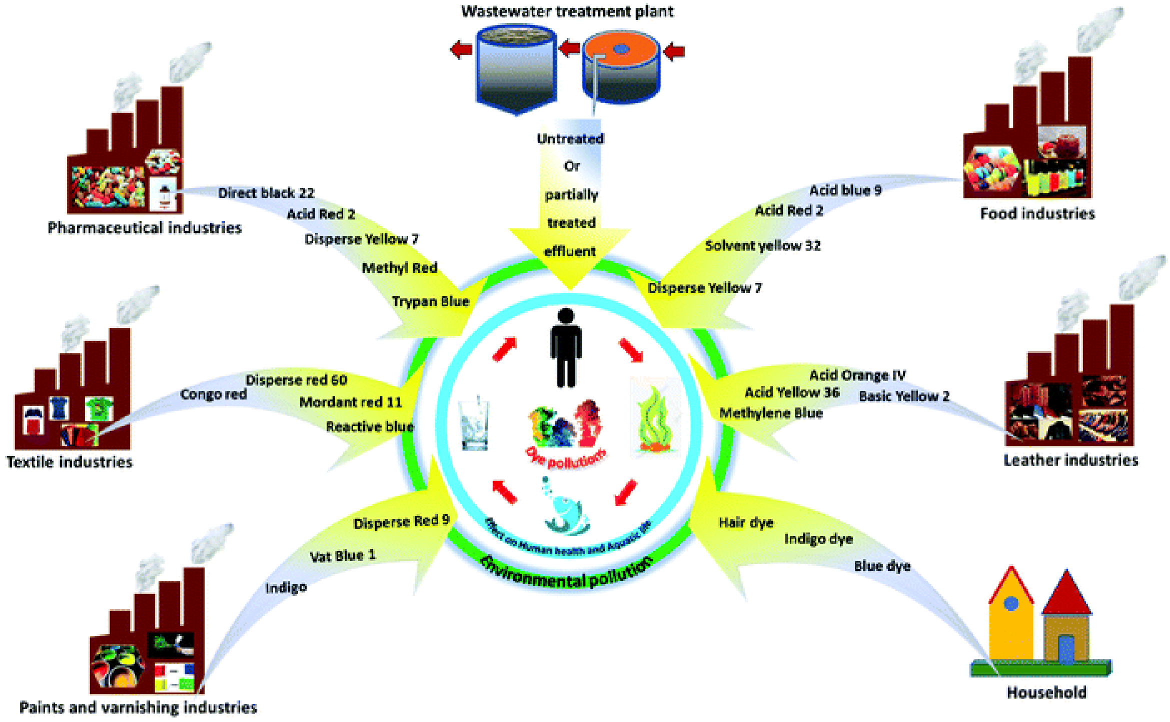
Contextualization

COLORANTS: molecules used to impart color, enhance or restore the appearance of products, which are used extensively in the food, cosmetic, pharmaceutical and textile industries.




- synthetic/artificial
- nature-identical
- natural colorants



Sources and pathways of colorants in the environment. Source: Dutta et al., 2021, DOI: 10.1039/d1ma00354b

Contextualization

NATURAL COLORANTS

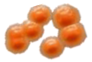
Insect

Microorganisms

Bacteria

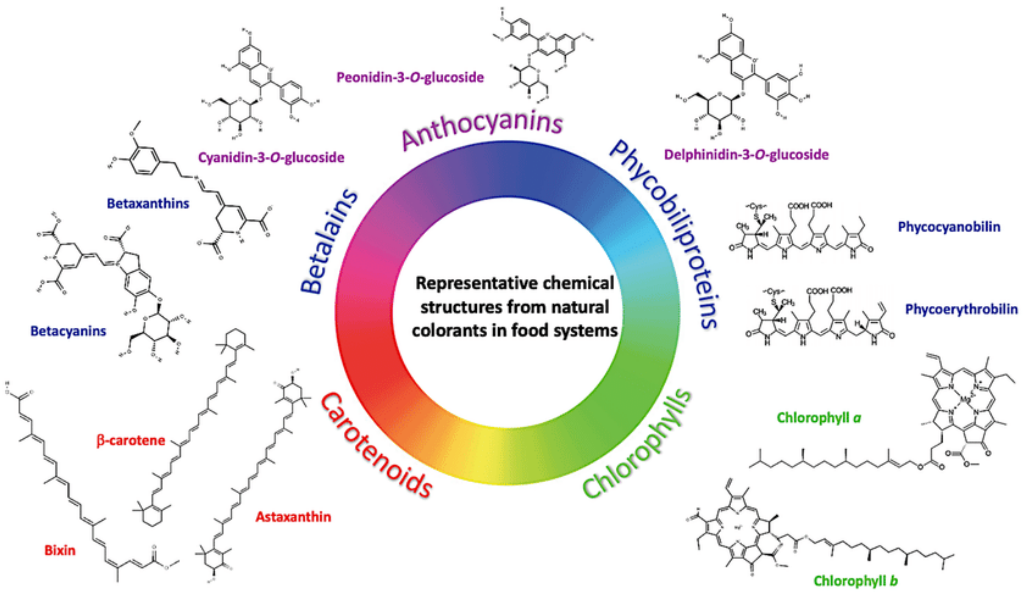
Algae

Yeast



Filmentous fungi

Plants



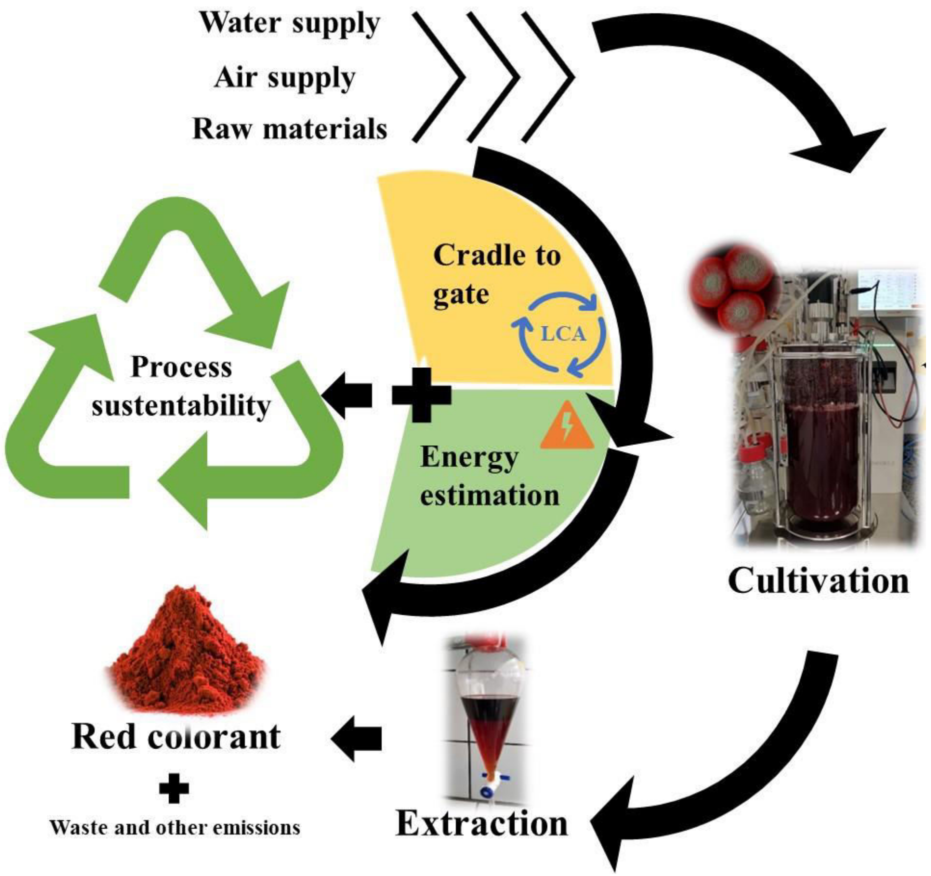
The development of biotechnology and bioprocesso engineering make the production of natural colorants by microorganisms interesting from an industrial point of view:

- can secure the production of the metabolite concerned, followed by controlled conditions, without the influence of free external factors and seasonal raw material supply;
- capable of minimizing batch-to-batch variations;
- often are more stable and soluble than similar products extracted from plants or animals;

Representative chemical structures from the most common types of natural colorants applied in food systems. Luzardo-Ocampo et al., 2021. DOI: 10.3390/foods10030634

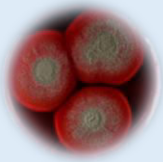
Objective

The goal of the study was to produce red colorants (RC) by *Talaromyces amestolkiae* in bioreactor and to estimate the environmental impacts of this process using life cycle assessment (LCA).



Materials and methods

Production step



Pre-inoculum – *Talaromyces amestolkiae*
30°C/7-days

Inoculum
30°C/150 rpm/7-days

Cultivation – Stirred tank bioreactor 4 L*
30°C/100 rpm/7-days

*Culture media composed of (g/L): MSG (5), glucose (10), $MgSO_4$ (0.012), $FeSO_4$ (0.010), $CaCl_2$ (0.015), pH 5.0

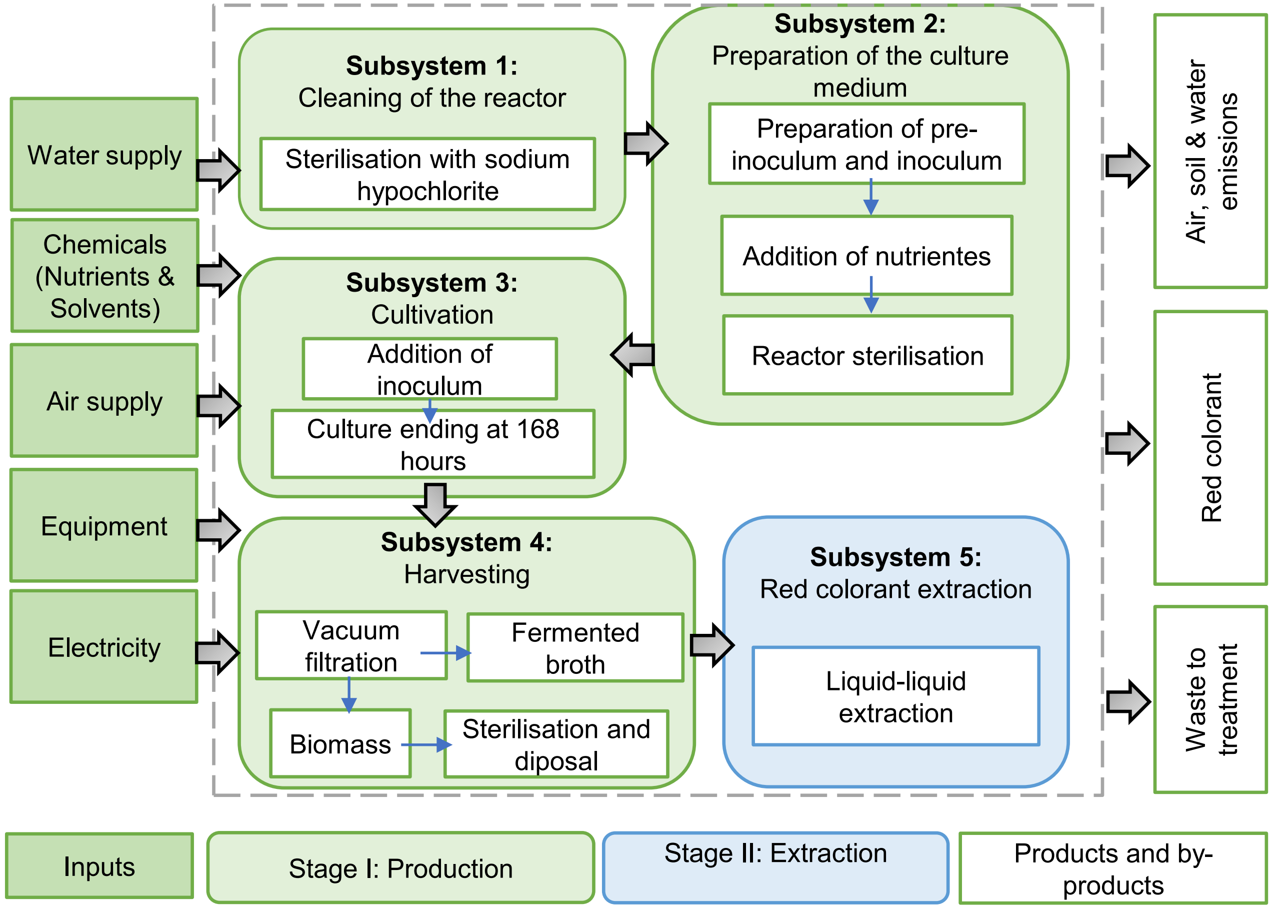
Extraction step

Materials and methods

ENVIRONMENTAL SUSTAINABILITY ASSESSMENT

- EE impellers with constant airflow at a rate of 4.0 $Lmin^{-1}$, operating at 30 ºC and 100 rpm for a total of 7 days (168 h)

- The life cycle inventory data for all background systems were sourced from the Ecoinvent V3.5 database



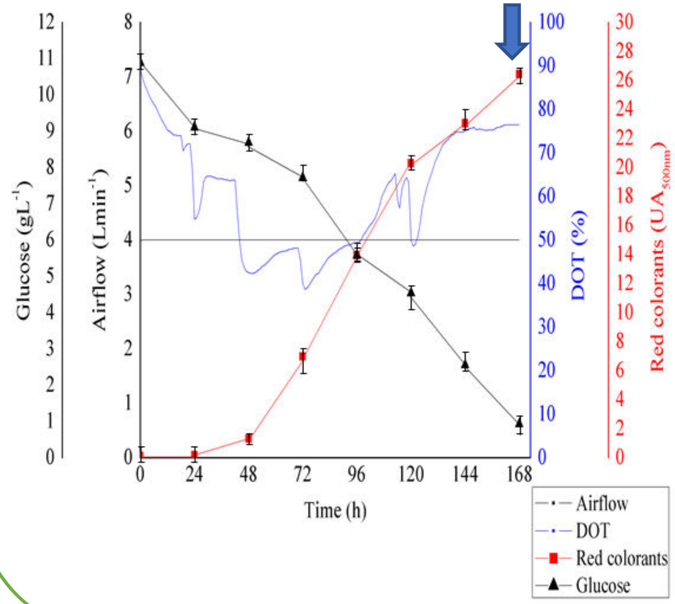
System boundaries and process description for the production of red colorant from *T. amestolkiae*.

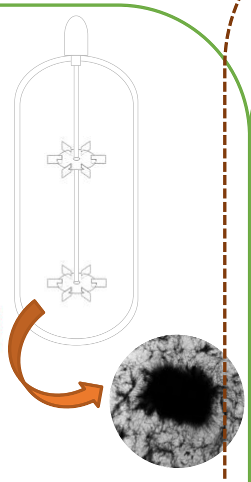
Results and discussion

COLORANTS PRODUCTION

A) Rushton turbine constant airflow experiment

26.4 ± 0.04 UA

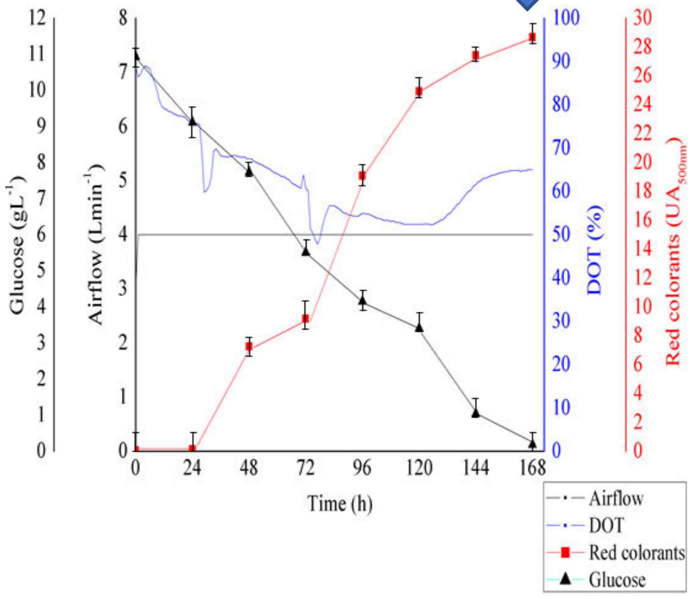


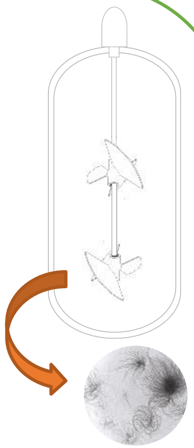


Hairy pellets formation. Magnification of 40X

B) EE impellers constant airflow experiment

28.7 ± 0.02 UA

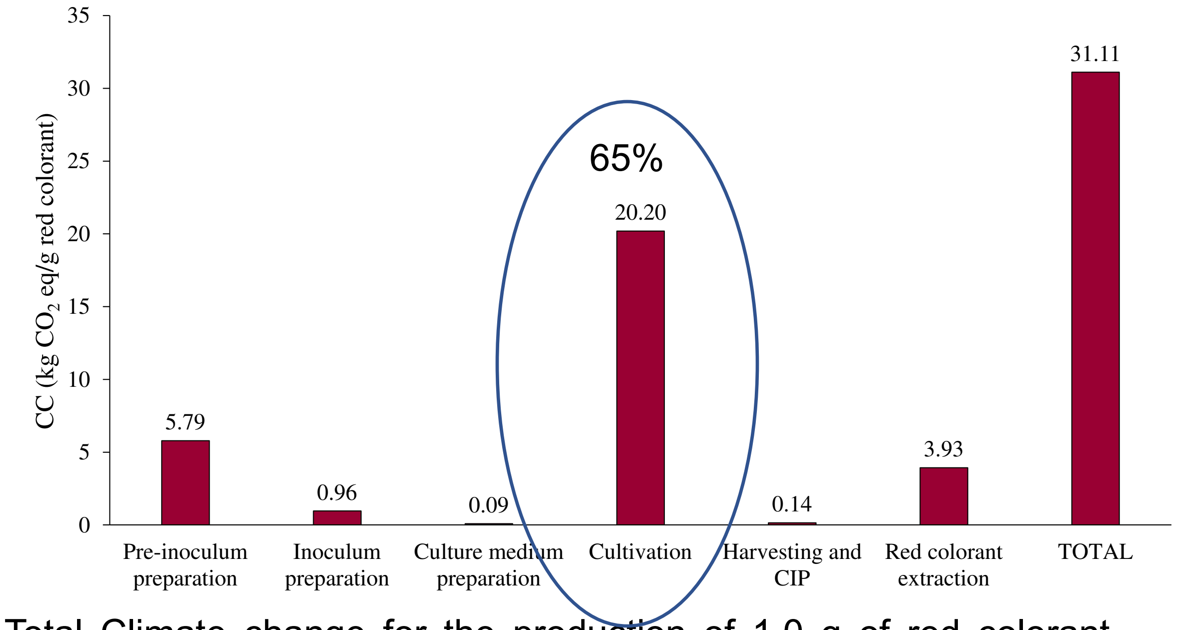




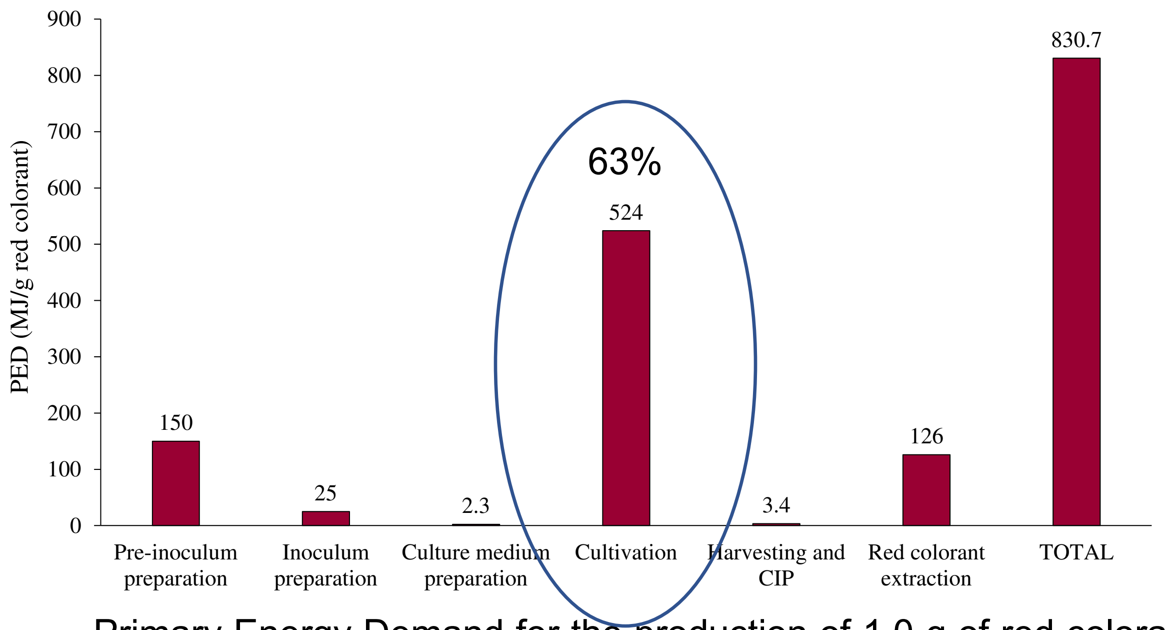
Dense pellets formation. Magnification of 40X

Results and discussion

ENVIRONMENTAL SUSTAINABILITY ASSESSMENT



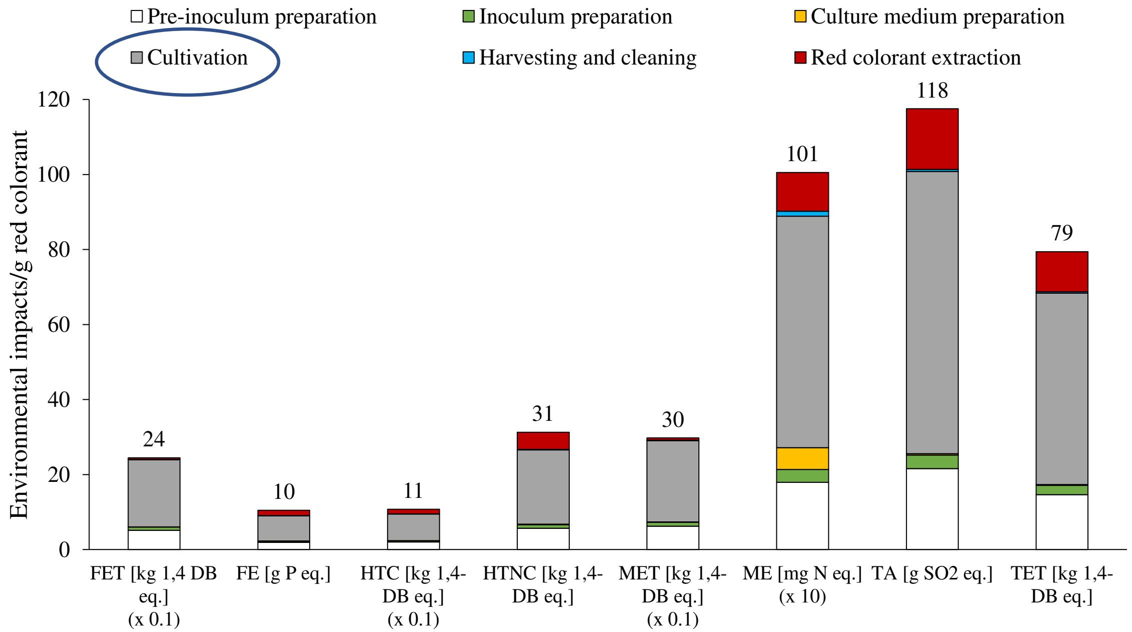
Total Climate change for the production of 1.0 g of red colorant from cultivation of *T. amestolkiae.*



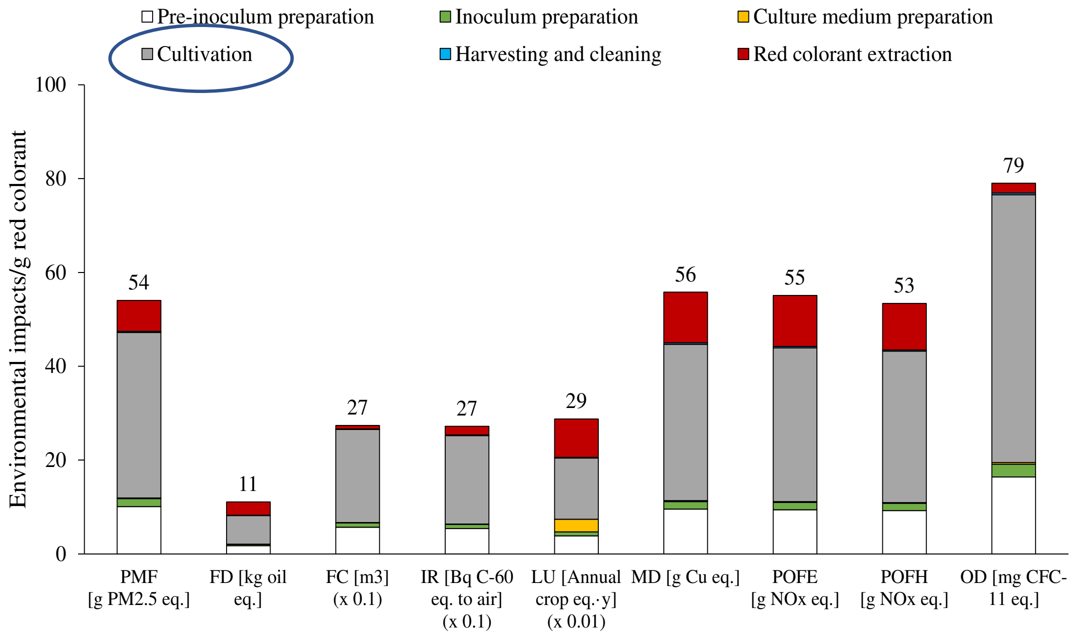
Primary Energy Demand for the production of 1.0 g of red colorant from cultivation of *T. amestolkiae.*

Results and discussion

ENVIRONMENTAL SUSTAINABILITY ASSESSMENT



Acidification (TA), eutrophication (FE, ME), and toxicity (FET, HTC, HTCN, MET, TET) environmental impacts for the production of 1.0 g of red colorant from cultivation of *T. amestolkiae*. [(TA) Terrestrial acidification; (FE) Freshwater eutrophication; (ME) Marine eutrophication; (FET) Freshwater ecotoxicity, (HTC) Human toxicity, cancer; (HTNC) Human toxicity, non-cancer; (MET) Marine ecotoxicity; (TET) Terrestrial ecotoxicity].



Other environmental impacts (PMF, FD, FC, IR, LU, MD, POFE, POFH, OD) for the production of 1.0 g of red colorant from *T. amestolkiae*. [(PMF) Fine particulate matter formation; (FD) Fossil depletion; (FC) Freshwater consumption; (IR) Ionizing radiation; (LU) Land use; (MD) Metal depletion; (POFE) Photochemical ozone formation, ecosystem; (POFH) Photochemical ozone formation, human health; (OD) Stratospheric ozone depletion].

Cultivation occurs for 168 h – main problem - eletricity

Conclusion

- The environmental sustainability assessment indicated that the cultivation stage is a major hotspot in the red colorant production process by *Talaromyces amestolkiae mainly* due to bioprocess time (168 h) and the associated energy requirements.

Future studies

The environmental performance of this process can be further improved by optimizing the duration of the cultivation stage with respect to the yield.

The use of low-carbon energy sources could also lead to significant impact reductions and other improvements can be achieved from switching to more sustainable solvents and scaling up, e.g. solvent recycling, heat losses reductions.

Acknowledgments

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Thank you for your attention!

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