Integral use of aromatic plants: prefeasibility comparison of stand-alone and biorefinery processes using thyme (*Thymus vulgaris*) as base case

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Introduction

30%

40%

30%

Aromatic plants

4 Jobs/ha

The Colombia potential is found in climatic advantages and soil use [1, 2]

Thyme (*Thymus vulgaris*)

It is among the most produced species in Colombia, which is found in different areas of the country.

The multiple extractive components that thyme contains make it have a potential for use towards different value-added products.

Polyphenolic compounds and essential oil are important due to they have a wide range of biological functions [3].

Phenolic Compounds

Benefits for human health

- **Antioxidant activity** protecting against chronic-degenerative
- **Antimicrobial capacity** with benefits for the immune system
- **Antithrombotic properties** due to the inhibition of platelets aggregation
- **Anti-inflammatory** and **Antiallergenic** effects

Extraction

- Conventional methods
- Green technologies

Waste management: biogas production

Currently the energy requirements have been increased

Biogas from wastes plays an important role in energy generation

It can replace conventional fuels to produce heat and energy or used as gaseous fuel

The aim of this work

Thyme

Solvent extraction

Remaining of thyme extraction

Anaerobic digestion

Phenolic extract

Biogas

Stand-alone process

Biorefinery process

Methodology: characterization

Chemical analysis

Extractives NREL/TP-510-42619
Holocellulose ASTM D1104
Cellulose T 203 os-74
Lignin T 222 os-74
Ash NREL/TP-510-42622

The results of the composition were used as initial data in the simulation section

Solid analysis

Total solids ASTM E1756-08
Volatile solids ASTM E1756-08

The anaerobic digestion conditions were fixed with these results

Phenolic compounds extraction: solvent extraction

-Ratio solvent-solid 20:1 (v:w)
-Solvent: ethanol 60%
-Time: 3 hours
-Temperature: 40°C
-150 rpm [7, 8]

Biogas production: anaerobic digestion

Spent Thyme

Standard method VDI 4630

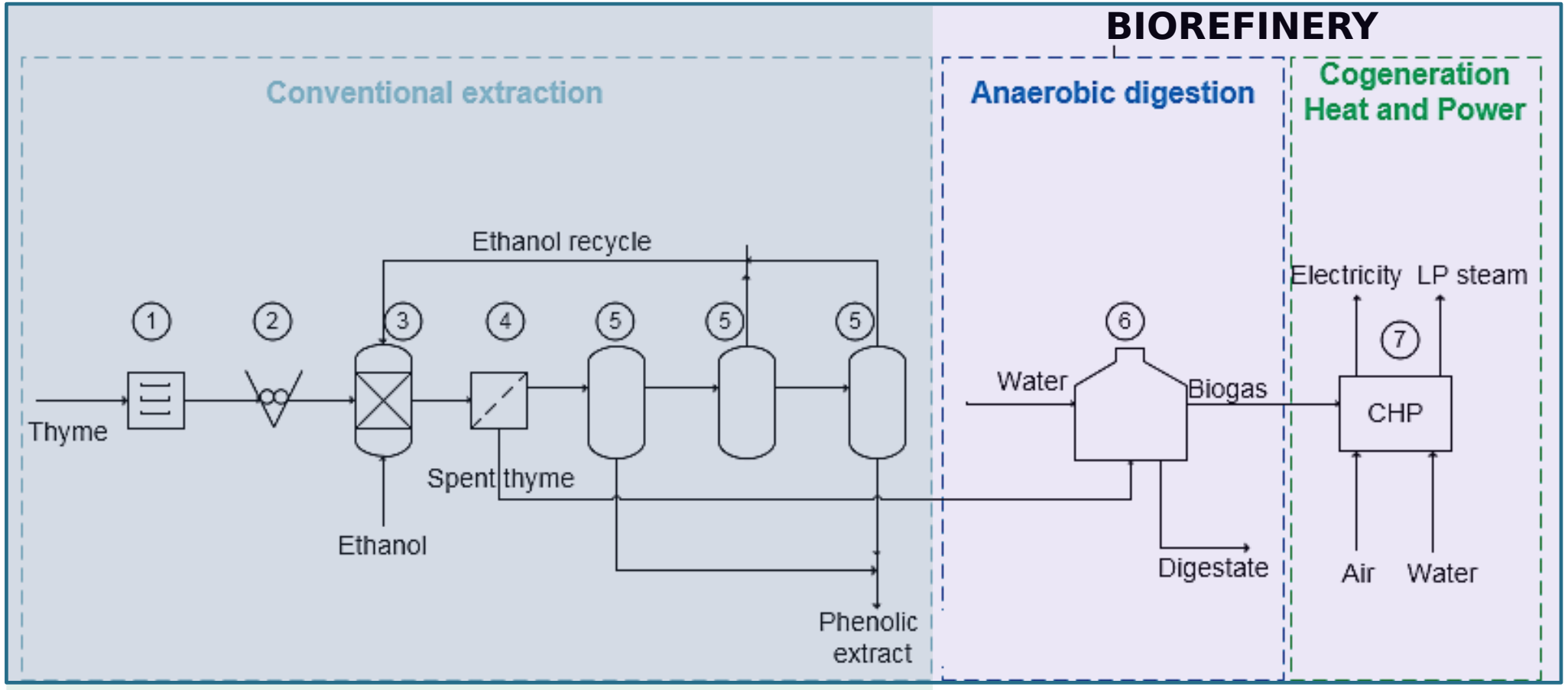
Temperature: 37°C

Time: 15 days

Gases analysis

Gases analyzer Gasboard - 3100P

Process flow diagram for simulation



1. Dryer
2. Mill
3. Extraction vessel
4. Filter
5. Evaporator
6. Anaerobic digestor
7. Cogeneration system

Processes simulation

Simulation of stand-alone and biorefinery processes were performed using Aspen Plus software. The mass and energy balances were obtained.

Economic assessment

It is estimed with Aspen Process Economic Analyzer considering the conditions of Colombian context and 10 years of project lifetime. The scale analysis was made by calculating the Net Present Value (NPV).

Environmental assessment

It was performed using the software WAR GUI. The Potential Environmental Impact (PEI) was obtained. There are two categories: global atmospheric impact and the local toxicological impact.

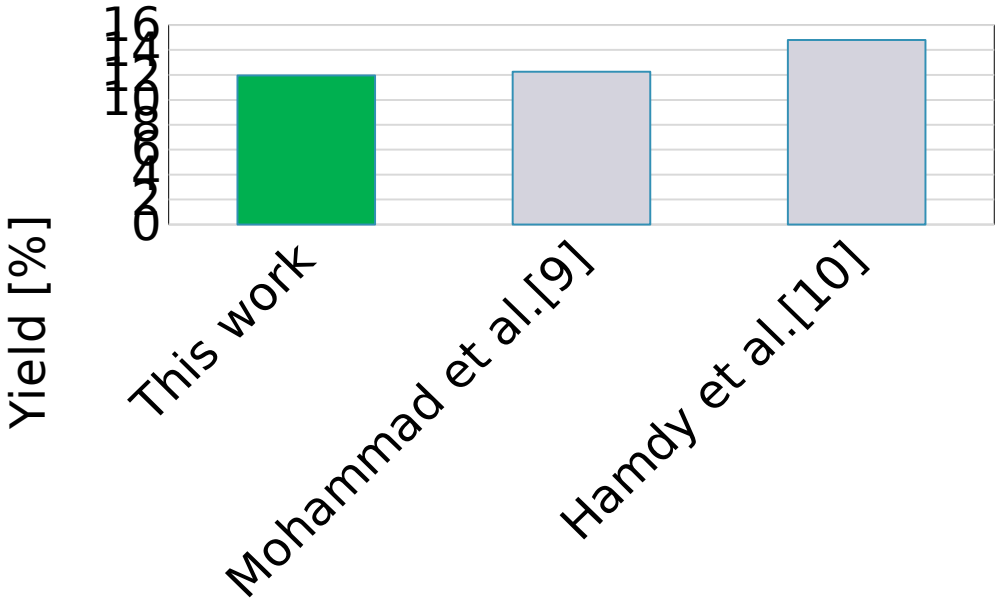
Results

Chemical characterization

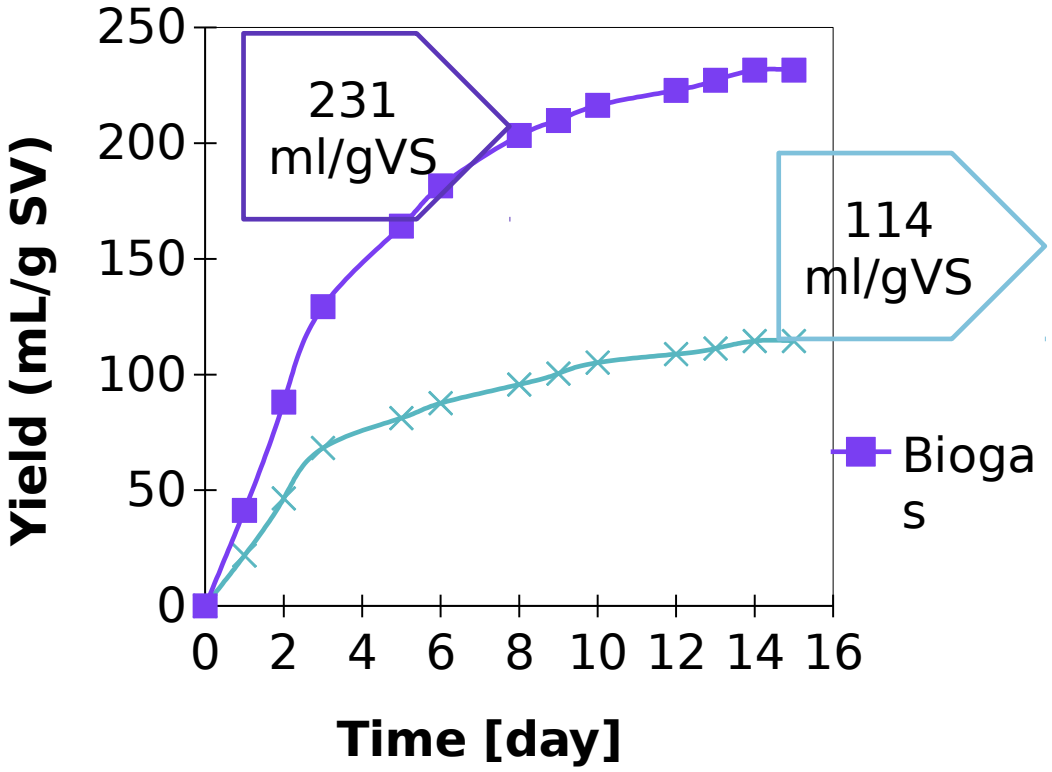
Characterization of thyme (%w/w dry basis)

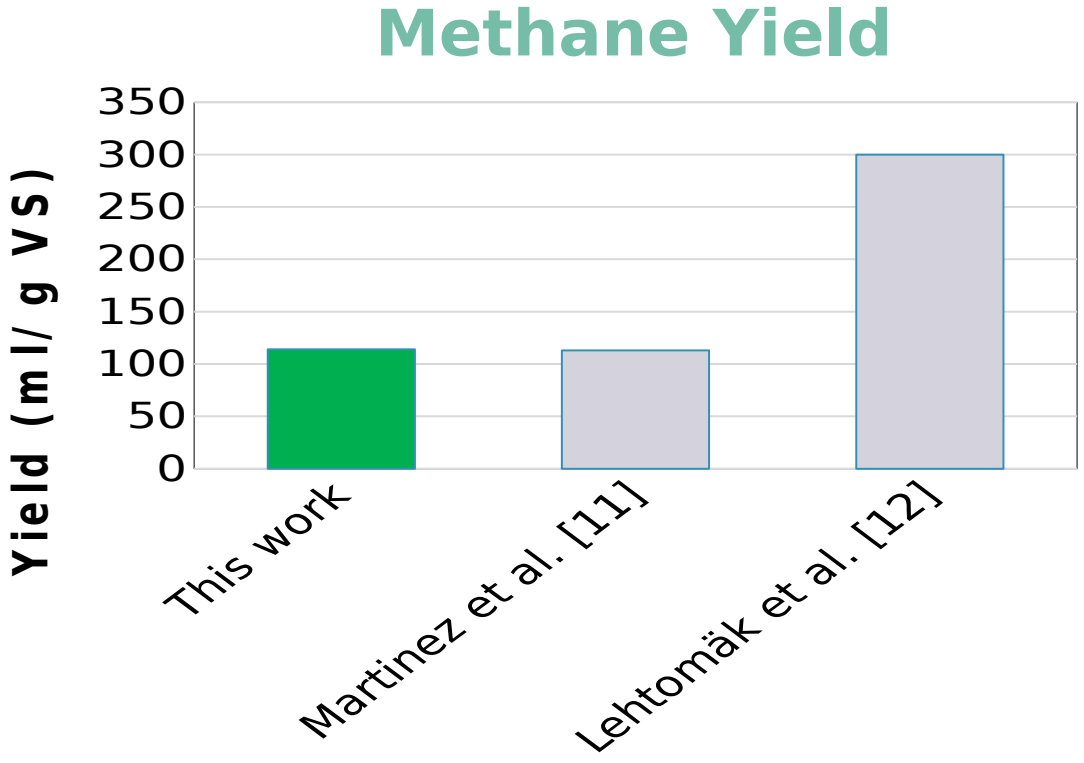
Component	Percentage [%]
Extractives	31.28 ± 1.19
Cellulose	31.52 ± 2.04
Hemicellulose	17.04 ± 1.96
Lignin	14.87 ± 1.01
Ash	5.29 ± 0.09
Total solids	29.54 ± 1.49
Volatile solids	27.05 ± 0.38
Moisture*	75.29
*Moisture of fresh raw material	

Extraction yield of phenolic compounds

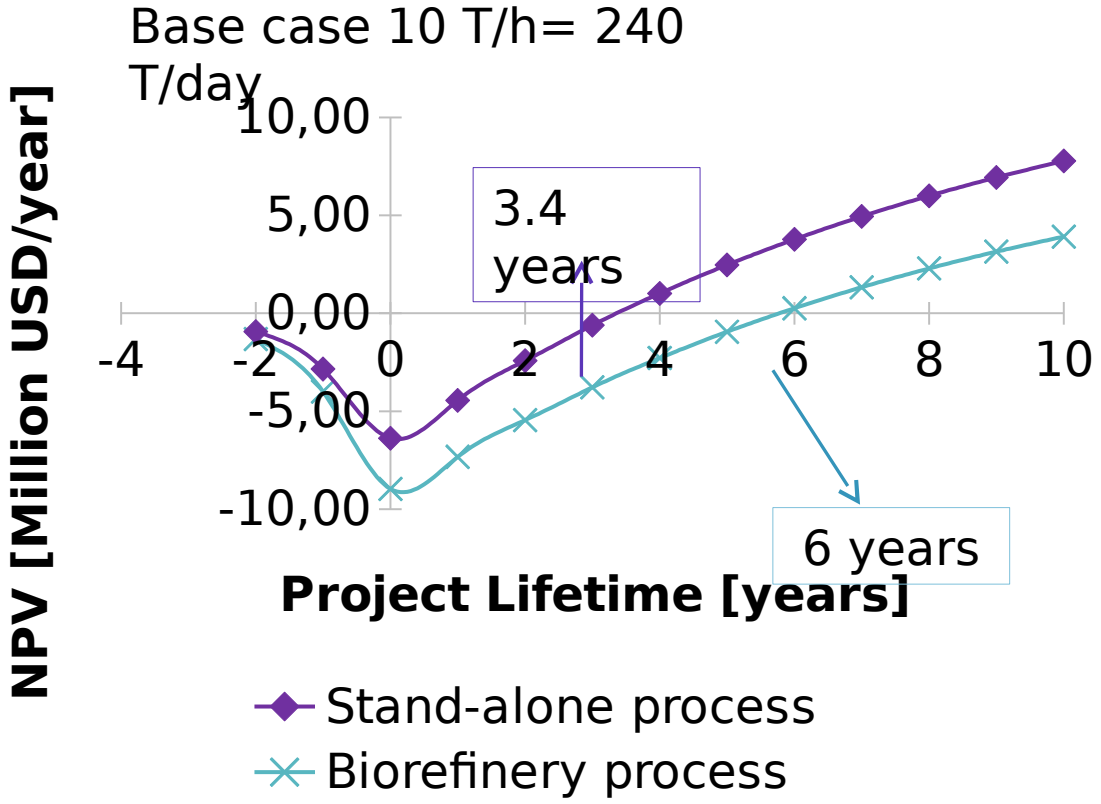


Results: Biochemical Methane Potential (BMP)





Economic comparisson between stand-alone and biorefinery processes

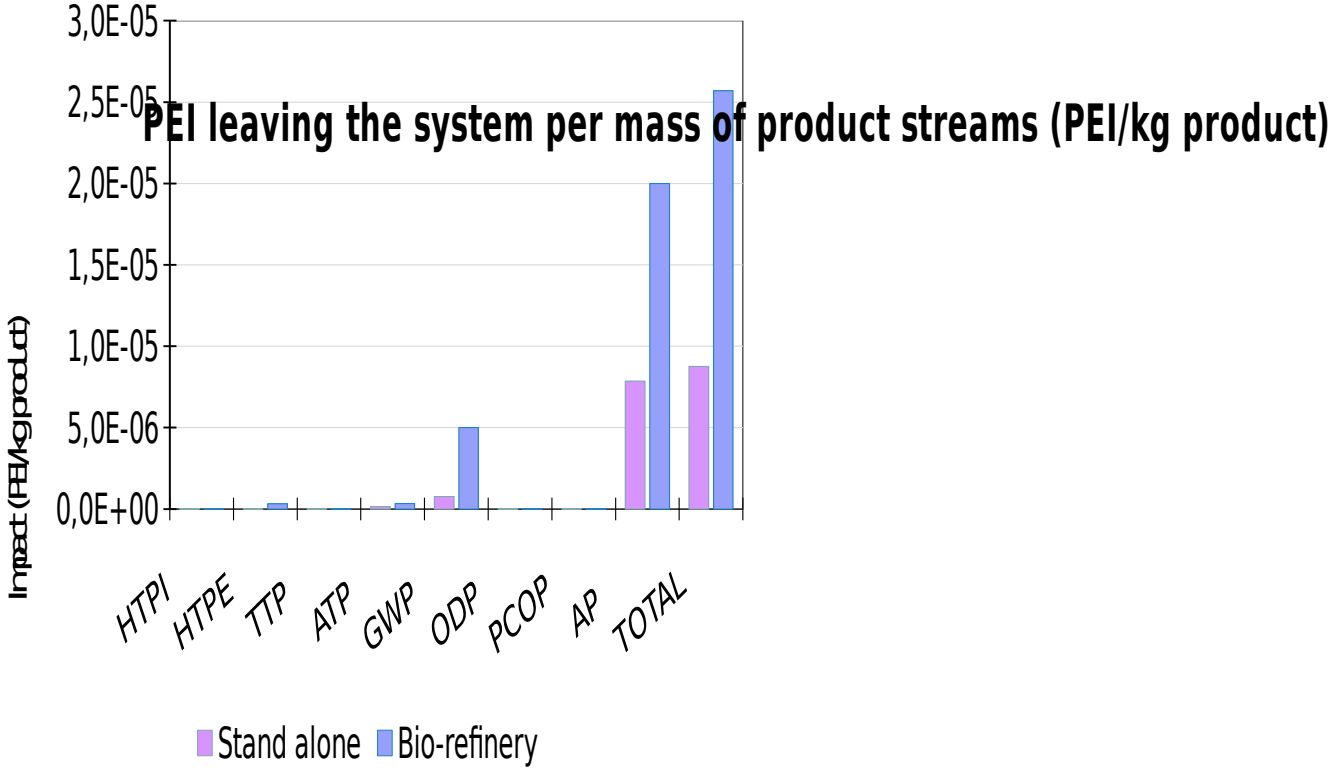


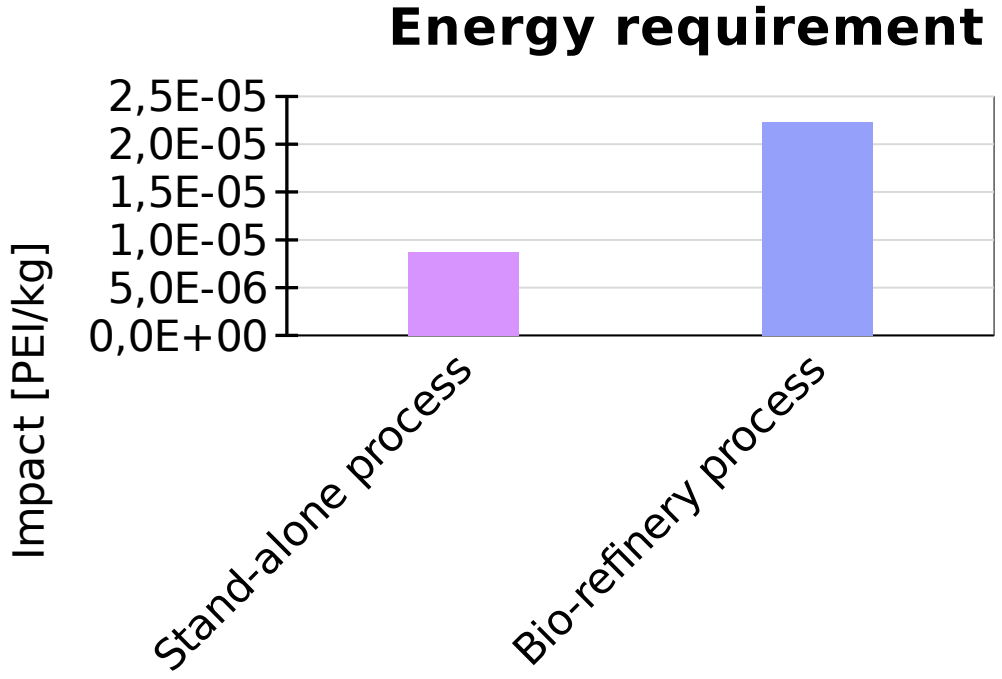
100% Cooling water requirements

100% Electricity requirements

1% Steam requirements

Environmental comparisson between stand-alone and biorefinery processes





Global Warming Potential (GWP), Ozone Depletion Potential (ODP), Acidification Potential (AP), and Photochemical Oxidation Potential (PCOP), Human Toxicity Potential by Ingestion (HTPI), Human Toxicity Potential by either inhalation or dermal exposure (HTPE), Aquatic Toxicity Potential (ATP), and Terrestrial Toxicity Potential (TTP).

Conclusions

-The results showed the pre-feasibility to extract antioxidant compounds from thyme as raw material by solvent extraction through stand-alone way at different scales. However, in the case of the biorefinery approach a very high scales are required .

-The conditions proposed in this paper, make the stand-alone process approach more viable than the biorefinery approach. However, there are different ways to do the biorefinery process more profitable based on the use of more efficient extraction and energy technologies. Additionally the key point is the interest for the total use of raw materials to avoid contamination.

-Other important aspect assessed in this study case is the Potential Environment Impact (PEI) as environmental indicator. It was achieved less PEI in the stand-alone than biorefinery approach. It is possible to affirm that a large part of the environmental impact potential is due to energy consumption.

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THANKS FOR YOUR ATTENTION

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