

# Life Cycle Assessment of Extract Production from *Cannabis sativa* Inflorescences: A Preliminary Study

J. Ortigueira <sup>1</sup>, M. Azevedo <sup>1</sup>, M. Paulo <sup>2,3</sup>, J. Bernardo <sup>2,3</sup>, S. Salavisa <sup>2</sup>, H. Monteiro <sup>1</sup>

<sup>1</sup> Low Carbon & Resources Efficiency, R&Di, Instituto de Soldadura e Qualidade, Portugal

<sup>2</sup> R&D Laboratory, Portocanna S.A., Santarém, Portugal

<sup>3</sup> REQUIMTE/LAQV, Laboratory of Pharmacognosy, Department of Chemistry, Faculty of Pharmacy, University of Porto, Portugal.

Presenting author email: [maazevedo@isq.pt](mailto:maazevedo@isq.pt)

*Cannabis sativa*, commonly known as cannabis, has been recognized by the scientific community for its analgesic, anti-inflammatory, and calming properties. In the past decades, the identification of its bioactive compounds has driven growing interest in its applications across various fields, particularly in medicine (Aguzzi et al., 2023; Leinen et al., 2023). The cannabis plant is characterized by a complex chemical composition that includes flavonoids, terpenoids, phytocannabinoids, alkaloids, glycoproteins, and phytosterols. Among these constituents, cannabinoids have attracted the greatest attention, particularly tetrahydrocannabinol (THC) and cannabidiol (CBD) (Leinen et al., 2023).

The identification of the endocannabinoid system, which interacts with cannabis phytoconstituents, has provided a scientific framework for understanding its effects on the human body, including the immune system and the central nervous system (CNS). This has supported the exploration of its potential medical applications, including the management of conditions such as epilepsy, Parkinson's disease, Alzheimer's disease, cancer, skin disorders, and post-traumatic stress disorder (Israni et al., 2024; Leinen et al., 2023; Obchoei & Limtrakarn, 2024). However, the conversion of these bioactive compounds into consistent medicinal products, such as cannabis oils and other extracts, requires efficient extraction and strict standardization processes.

The extraction of cannabis oil, from both the seed and the inflorescence of the Cannabis plant, traditionally involves the use of butane as a solvent in a solid-liquid extraction system. This method is typically associated to yields between 15% and 20% (total THC/CBD concentration) and presents significant safety concerns, as butane is a highly flammable and toxic gas, not only posing risks of explosion but also significant hazards to human health during handling and storage (Díaz & Dávila, 2025). The most common replacement for its usage is ethanol which, not only attains particularly high recovery yields (approximately 76% of total cannabinoid concentration) as its use is recognizably safer (GRAS solvent). Additionally, ethanol is generally cheaper when compared to butanol and its use does not require high-pressure operating conditions (Díaz & Dávila, 2025; López-Olmos et al., 2022).

Despite growing interest in this product, the environmental performance of inflorescence-derived cannabis oil process remains insufficiently characterized. A cursory examination of common scientific databases identifies published sustainability studies on cannabis valorization but that focus mainly on the seed conversion (Devi & Khanam, 2019; Díaz & Dávila, 2025). This observation limits the availability of robust evidence to support decision-making in the industry. It is within this context, that the CannValue project was developed to operate. The CannValue project wishes to develop a safe, reliable and sustainable process for the production of cannabis oil from inflorescences and investigate potential waste management and valorization routes. This procedure will include the optimization of the ethanol-based extraction, the application of Supercritical carbon dioxide as a possible alternative to the conventional solid-liquid extraction and the valorization of waste streams of the process as to improve environmental and economic performance. The production development will be supported by the Life Cycle Assessment task (LCA), whose main objective will consist in the identification of key environmental impact hotspots, optimization opportunities and design of the appropriate end-of-life scenarios.

The present work was developed under the scope of the CannValue project and presents the initial findings of the environmental assessment of edible oil from cannabis inflorescences for use in the pharmaceutical industry. The process model was developed using a cradle-to-gate approach, encompassing all unit processes from plant cultivation up to oil formulation, prior to introduction into the market. Calculations relied on primary data acquisition from the partner companies. Preliminary results identified the following hotspots: use of diesel for agricultural production, application of ethanol as solvent for oil extraction stage, incineration of exhausted biomass and the generalized use of electricity. From the primary hotspots, ethanol was considered the most problematic issue to be addressed, as its use was responsible for approximately 53% of the total climate change (CC) value. Future studies will focus on the possible recovery and recirculation of this component, taking into consideration existing quality guidelines associated with the pharmaceutical use of the final product (European Medicines Agency (EMA), 2013). A secondary optimization point focused on the potential of the exhausted biomass at the

end of the oil extraction step. Current legislation on cannabinoids concentration limits forces biomass disposal through incineration as a hazardous material. This study compared the possible environmental benefit in the replacement of the disposal route with biomass treatment as green residue or valorization through anaerobic digestion, signaling a potential reduction in approximately 20% in CC value if the cannabinoid concentration is within legal limits. Additional pretreatments will be considered during the operation of the CannValue project as to guarantee this factor.

The preliminary findings underscore the value of conducting LCA iteratively during process development and optimization, while also revealing the often-overlooked influence of operational parameters on the environmental performance of the assessed system.

## References

- Aguzzi, C., Perinelli, D. R., Cespi, M., Zeppa, L., Mazzara, E., Maggi, F., Petrelli, R., Bonacucina, G., & Nabissi, M. (2023). Encapsulation of Hemp (*Cannabis sativa* L.) Essential Oils into Nanoemulsions for Potential Therapeutic Applications: Assessment of Cytotoxicological Profiles. *Molecules*, *28*(18), 6479. <https://doi.org/10.3390/molecules28186479>
- Devi, V., & Khanam, S. (2019). Comparative study of different extraction processes for hemp (*Cannabis sativa*) seed oil considering physical, chemical and industrial-scale economic aspects. *Journal of Cleaner Production*, *207*, 645–657. <https://doi.org/10.1016/j.jclepro.2018.10.036>
- Díaz, M. P., & Dávila, J. A. (2025). Cannabis oil extraction process and potential applications of lignocellulosic residues. A techno-economic assessment under the biorefinery concept. *Bioresource Technology Reports*, *31*, 102252. <https://doi.org/10.1016/j.biteb.2025.102252>
- European Medicines Agency (EMA). (2013, December 3). *Reflection paper on the use of recovered/recycled solvents in the manufacture of herbal preparations for use in herbal medicinal products / traditional herbal medicinal products*. <https://www.ema.europa.eu/en/homepage>
- Israni, D. K., Raghani, N. R., Soni, J., Shah, M., Prajapati, B. G., Chorawala, M. R., Mangmool, S., Singh, S., & Chittasupho, C. (2024). Harnessing Cannabis sativa Oil for Enhanced Skin Wound Healing: The Role of Reactive Oxygen Species Regulation. *Pharmaceutics*, *16*(10), 1277. <https://doi.org/10.3390/pharmaceutics16101277>
- Leinen, Z. J., Mohan, R., Premadasa, L. S., Acharya, A., Mohan, M., & Byrareddy, S. N. (2023). Therapeutic Potential of Cannabis: A Comprehensive Review of Current and Future Applications. *Biomedicines*, *11*(10), 2630. <https://doi.org/10.3390/biomedicines11102630>
- López-Olmos, C., García-Valverde, M. T., Hidalgo, J., Ferrerio-Vera, C., & Sánchez De Medina, V. (2022). Comprehensive comparison of industrial cannabinoid extraction techniques: Evaluation of the most relevant patents and studies at pilot scale. *Frontiers in Natural Products*, *1*, 1043147. <https://doi.org/10.3389/fntpr.2022.1043147>
- Obchoei, T., & Limtrakarn, W. (2024). Axisymmetric flow model of cannabis oil extraction of supercritical fluid extraction CO<sub>2</sub> process. *International Journal of Thermofluids*, *22*, 100682. <https://doi.org/10.1016/j.ijft.2024.100682>

## Acknowledgements

This work was financially supported under the project CANNVALUE - “Valorização de subprodutos do processo de extração de Canabinoides e suas aplicações”, project number 17466, co-financed by the European Union through the Innovation and Digital Transition Program – COMPETE2030-FEDER-01203300, LISBOA2030-FEDER-01203300 e ALGARVE-FEDER-01203300 and the Portugal 2030.