

Iaquis Conference Proceedings

*Fostering organizational transformation for a
sustainable future:
Enhancing synergies between quality, innovation and
sustainability*



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Viterbo, Italy

Iaquis Conference Proceedings

Iaquis Conference 2024

**Fostering organizational transformation for a
sustainable future:**

**Enhancing synergies between quality, innovation and
sustainability**

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Foreward

The current economic, social, and environmental landscape is marked by a profound crisis, underscoring the urgent need for a paradigm shift in production and consumption patterns. The interconnectedness of these domains has become increasingly evident, with the effects of unsustainable practices rippling through economies, societies, and ecosystems.

Recent environmental and geopolitical events have further highlighted the fragility of the existing production system. Climate change, resource depletion, and geopolitical tensions have exposed the vulnerabilities of traditional economic models and the imperative for transformative action. Organizations must adapt to these challenges by embracing sustainable practices and innovating to create more resilient and equitable systems.

A synergistic contribution from academics, practitioners, and policymakers is essential to navigate this complex landscape. Academics can bring their research expertise to identify emerging trends, develop innovative solutions, and inform policy decisions. Practitioners can offer insights into the practical challenges and opportunities faced by organizations in their respective sectors. Policymakers can create enabling environments that support sustainable practices and incentivize innovation.

Academia, in particular, can play a pivotal role in driving the development of new ideas through research activities. The International Association of Quality, Innovation, and Sustainability (IAQUIS) can serve as a valuable platform for aggregating, coordinating, and mediating these efforts. By fostering collaboration among professors, researchers, doctoral students, and practitioners from around the world, IAQUIS can facilitate constructive discussions and knowledge sharing.

The choice of the main themes, "Quality, Innovation, and Sustainability," reflects the interconnected nature of these concepts and their critical importance for a sustainable future. Quality, as a cornerstone of excellence and customer satisfaction, is essential for long-term organizational success. Innovation, as the driving force behind progress and adaptation, is crucial for addressing emerging challenges and creating new opportunities. Sustainability, encompassing environmental, social, and economic dimensions, is a fundamental imperative for ensuring the well-being of future generations.

By adopting a cross-cutting and synergistic perspective, organizations can unlock the full potential of quality, innovation, and sustainability. This involves integrating these elements into all aspects of business operations, from product design and production to supply chain management and customer relationships.

The First IAQUIS Conference provides a unique opportunity to initiate a network of relationships and connections among key stakeholders from academia, industry, and policymaking. Through collaborative discussions and knowledge sharing, participants can explore innovative approaches, identify best practices, and develop strategies for fostering organizational transformation.

By focusing on quality, innovation, and sustainability, IAQUIS aims to contribute to a more equitable, resilient, and sustainable future for all.

Viterbo, Italy

Alessandro Ruggieri

Preface

The first Iaquis Conference was held in Viterbo (Italy) from 11th to 13th September 2024. It was promoted by the International Association for Quality, Innovation and Sustainability and hosted by the Department of Department of Economics, Engineering, Society and Business Organisation of University of Tuscia in Viterbo, Italy.

The objective of the Conference was to stimulate and foster collaboration and knowledge exchange in the areas of Quality, Innovation and Sustainability among researchers, educators, practitioners, and doctoral students hailing from diverse countries and backgrounds.

Over the course of the three-day Conference, the participants had the opportunity to present their research in both plenary and parallel sessions.

The central theme that permeated all discussions revolved around the synergies between Quality, Innovation, and Sustainability, embracing an interdisciplinary perspective and a cross-cutting approach.

A pre-conference Doctoral Consortium was held. During the Doctoral Consortium the PhD Students presented their research program and findings, and received suggestions by the mentors. Moreover a seminar on how to develop an impactful paper was held to provide young scholars with in-depth feedback from experienced lecturers on their ongoing research.

The Conference collected a total of 83 Papers from 15 countries. Some of the authors asked not to be publish their paper in these proceedings, thus some contributions will not appear, besides being counted.

The great number of papers and the variety of the topics allowed us to organize numerous parallel sessions, by dividing the papers into 18 tracks, plus the Doctoral Consortium:

- 1) Circularity
- 2) Healthcare
- 3) Sustainability in Tourism
- 4) Sustainability in Agri-Food
- 5) Sustainability
- 6) Life Cycle Assessment
- 7) Quality and Innovation in Food Sector
- 8) Innovation Industry 4.0
- 9) Quality Management
- 10) TQM and Sustainability
- 11) TQM and Employees
- 12) Quality Management and Improvement
- 13) Management Systems
- 14) Life Cycle Assessment
- 15) Sustainability and Service Innovation
- 16) Sustainability
- 17) Sustainability in Energy Sector
- 18) Innovation.

Due to the conspicuous number of the papers which fell under the topics of “Sustainability” and “Life Cycle Assessment”, each of these parallel sessions were split in two sessions, allowing all the authors to present their contribution.

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Life Cycle Assessment in the cosmetic sector: critical issues related to life cycle inventory data availability

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Abstract

Life Cycle Assessment (LCA) is increasingly employed for assessing the potential environmental impact of cosmetic products. However, findings of a preliminary literature review on LCAs in the cosmetic sector showed that there are critical issues related to the availability of life cycle inventory data for many cosmetic ingredients. Missing data is a key challenge facing LCA studies, indeed the scarcity of complete and reliable inventory data may limit the effectiveness of the analysis. In this context, this study intends to further investigate the results emerging from the literature analysis and verify the availability of life cycle inventory data for cosmetic ingredients in some of the most known and used commercial databases, namely Ecoinvent, Agri-footprint, European Life Cycle Database (ELCD), World Food LCA Database (WFLDB), and United States Life Cycle Inventory (USLCI). Following this aim a case-study on a cosmetic product has been performed. Primary data of a cosmetic solar cream were collected, and a list of 18 ingredients (each composed by one or more substances) was identified. Secondary data on the resulting 28 substances contained in the ingredients were then searched in the databases. Preliminary results confirm that inventory data for almost all the substances are missing in the considered databases. In details, the few inventory data available concerns a total of 5 substances (4 in Ecoinvent and 1 in Agri-footprint), allowing to obtain secondary data for only 6 of the 18 identified ingredients. Substances similar to those for which the lack of inventory data occurs are identified, as already proposed by other scholars when performing LCAs with missing data.

Keywords: Life cycle assessment, cosmetic product, life cycle inventory, secondary data

Relevant Topic: Circular economy and sustainability

Introduction

The cosmetic industry is one important and fast-growing sector in the global economy (Statista, 2022). The sector is expected to continuously grow with an Average Growth Rate (CAGR) of 2.6% at European level, from 2022 to 2027 (Mordor Intelligence, 2021), and of 5.5% at global level, from 2021 to 2028 (Zion Market Research, 2021). However, as the sector grows, the environmental pressure related to the entire life cycle of cosmetic products increases as well (Cosmetics Europe, 2019).

In this context, a previous literature review carried out by the authors of this paper pointed out an increasing interest in sustainability and circular economy (CE) concepts of both companies and scientific community (Mondello et al., 2024). Particularly, the attention of companies regards solutions for mitigating the environmental impacts of all the phases of a cosmetic product's life cycle, i.e. sourcing, manufacturing, packaging, distribution, consumer use and post-consumer use, and disposal (Bom et al., 2019). Consequently, cosmetic companies started to use a Life Cycle Thinking (LCT) approach, and specifically the Life Cycle Assessment (LCA) method, to identify practices and strategies with a reduced environmental footprint along the whole life cycle of cosmetic products (Cosmetics Europe, 2019).

The LCA is a standardized method which allows to assess the environmental impacts of a product, a service or a process, along the entire life cycle (ISO, 2006a; ISO, 2006b). According to the International Organization for Standardization (ISO), the application of the LCA method includes four phases as follows: i) goal and scope definition, ii) life cycle inventory analysis, iii) life cycle impact assessment, iv) interpretation (ISO, 2006a). Each of these phases implies important methodological choices, for example the definition of a functional unit (FU) and system boundaries (SBs) for the goal and scope definition phase, or of the typology of data and related databases (DBs) for their collection for the life cycle inventory (LCI) phase.

However, methodological choices for carrying out LCA studies in the cosmetic industry are influenced by the complexity of the sector. For example, many issues arise regarding the availability of LCI data on cosmetic products' ingredients (e.g. Secchi et al., 2016). Indeed, cosmetic products are mainly composed by chemical substances, which could contribute to nearly all the life cycle impact assessment (LCIA) impact categories considered in a LCA case-study (Hauschild et al., 2013). However, many issues arise within the collection of chemical-related data due to the complexity of their synthesis and production processes (Fantke and Ernstoff, 2018). In addition, when performing an LCA of cosmetic products, many data on chemical substances may not be available to the manufacturer, thus sourcing data from suppliers may cause additional difficulties (Bjørn et al., 2018).

To the best of authors' knowledge, there is a lack of review studies which focus on the methodological choices for performing LCA case-studies of cosmetic products. In addition, studies which explicitly take into consideration the availability of inventory data for cosmetic products' ingredients are still missing.

Therefore, this study has two main aims: i) identify the main methodological aspects regarding LCA of cosmetic products, ii) verify the availability of LCI data for a cosmetic product.

Methods

Firstly, a scoping review (Arksey and O'Malley, 2005; Peters et al., 2015) is carried out for analysing the methodological aspects, emerging from the scientific literature, of applying LCA in the cosmetic industry. The aim is to identify the main characteristics and complexities that should be considered when modelling an LCA study of a cosmetic product.

The literature review is carried out according to the Preferred Reporting Items for Systematic Review and Meta-Analyses guidelines (PRIMA) (Moher et al., 2009). For the identification of the sample, a search query is defined for collecting all the studies which report LCA implementation in the cosmetic industry, as follows: "Life Cycle Assessment" OR "LCA" AND "cosmetic*". The query is employed on Scopus and Web of Science databases, using the search fields limited to title, abstract, and keywords. A time frame is not defined, but the search is updated on March 15, 2024.

The search strategy is summarized in Figure 1. A total of 222 studies are collected, of which 120 from Scopus and 102 from Web of Science. The sample is restricted to only articles and reviews published in English (n=191), then also duplicates (n=64) and full-text non available (n=8) are excluded. The abstract and full-text screening is performed, allowing to exclude further 89 studies according to specific exclusion criteria, i.e. i) LCA is not referred to Life Cycle Assessment; ii) a LCA case-study is performed, but not related to the cosmetic industry. Finally, other 24 studies are excluded due the object of the LCA case-study reported is not a cosmetic product, allowing to obtain a final sample of 7 studies, of which 6 articles and 1 review.

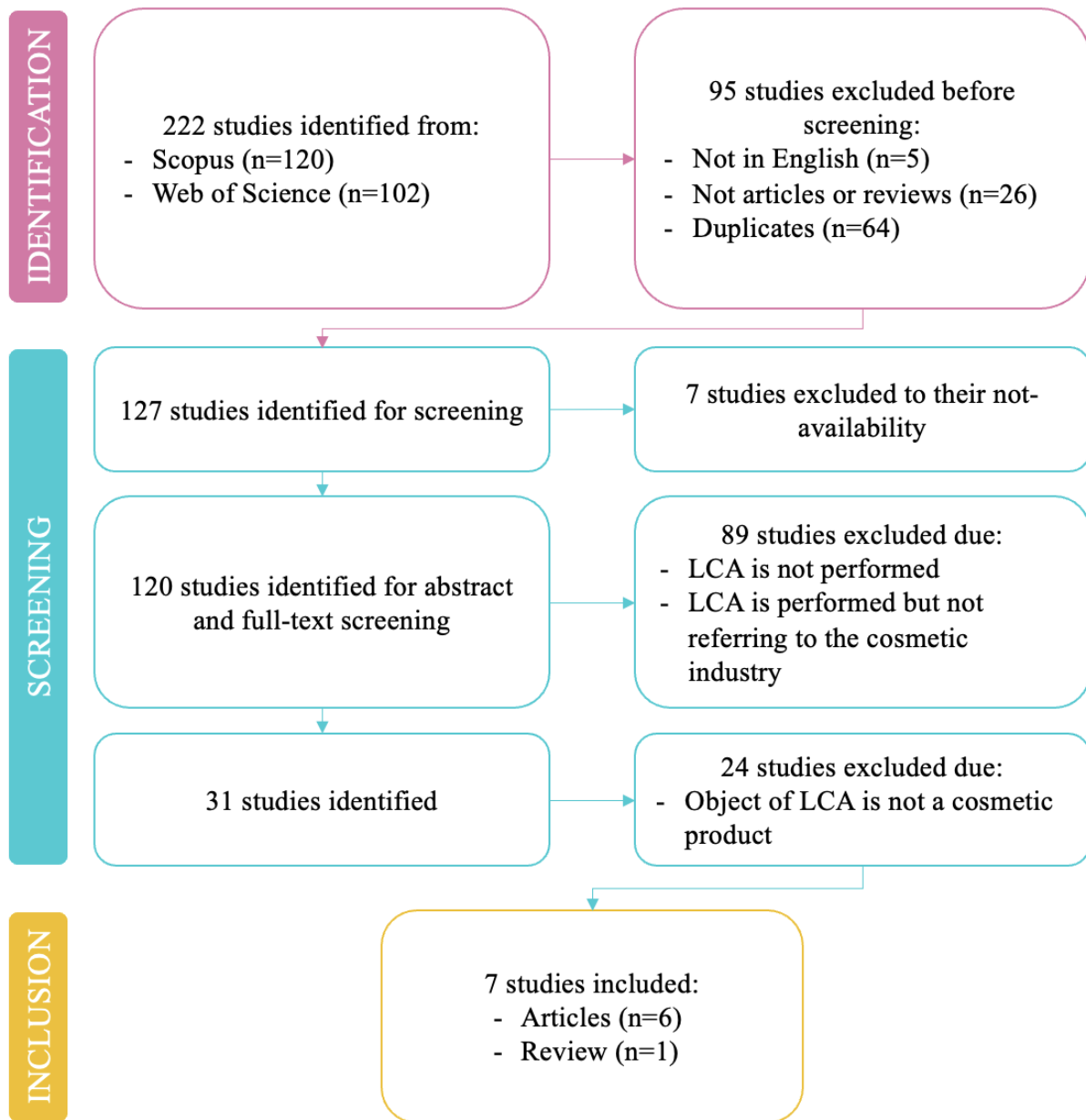


Figure 1. Search strategy of the scoping review (based on PRISMA).

Then, a LCA case-study (ISO, 2006a; ISO, 2006b; ISO, 2020a; ISO, 2020b) of a cosmetic product is performed according to the findings of the scoping review. Particularly, a focus on LCI phase is made due to the related critical issues found in literature.

The LCI of a cosmetic product, which is a solar cream, is carried out. All the input materials collected into the LCI are referred to 1 product, consisting of a 198 g bottle containing 200 ml of cream, which represents the functional unit. A cradle-to-gate approach is considered for defining the system boundaries, which include raw materials sourcing and manufacturing of the cream. The packaging process is excluded from this study due to the aim of verifying the availability of LCI data of cosmetic ingredients. The system boundaries are represented

in Figure 2, in which all the life cycle phases of a cosmetic product are represented according to the classification of Bom et al. (2019).

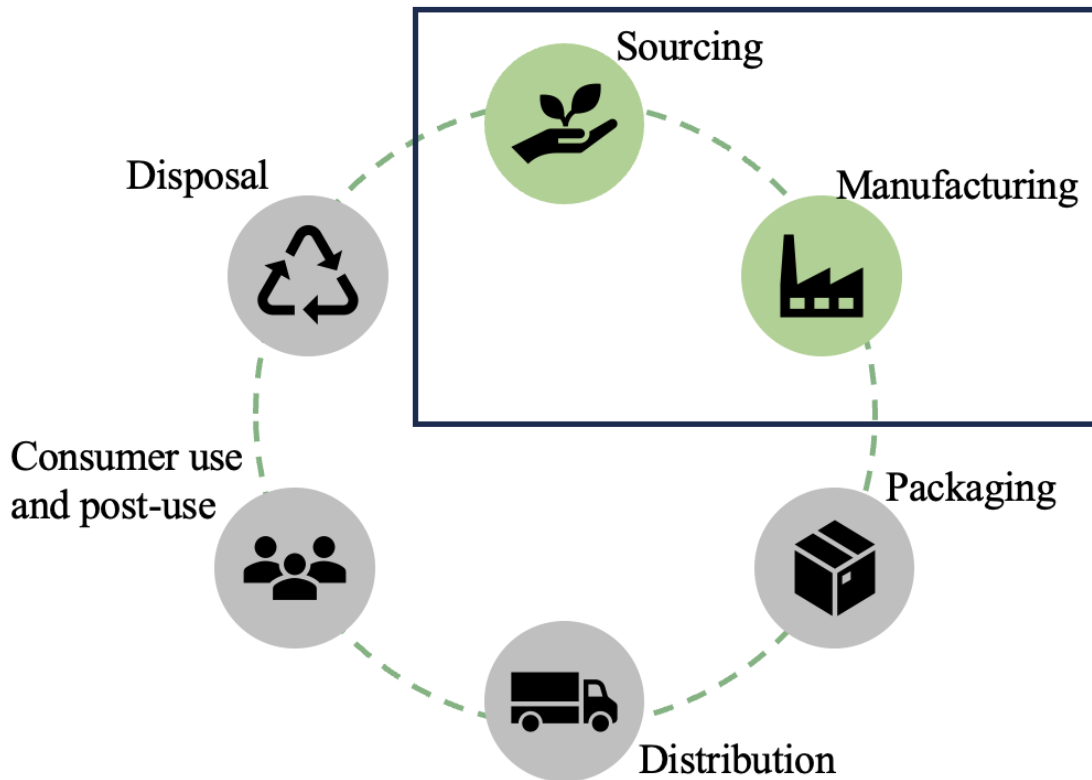


Figure 2. System boundaries of the LCA case-study of a cosmetic solar cream.

The LCI phase includes the collection of primary data and the search of secondary data. Primary data are collected from the productive plant of the cosmetic product, which is located in Central Italy. Secondary data are searched in some of the most known and used commercial databases, i.e. Ecoinvent, Agri-footprint, European Life Cycle Database (ELCD), World Food LCA Database (WFLDB), and United States Life Cycle Inventory (USLCI). The search is carried out using the SimaPro software (PRé Sustainability, 2024).

Results and Discussion

In this section, the results of the preliminary scoping review and of the LCI of the cosmetic solar cream are presented and discussed.

Regarding the scoping review, the analysis is carried out on the final sample of 7 studies reporting LCA case-studies of cosmetic products. Despite the small number of case studies available in the literature, in this paper the sample is used to extract first useful considerations for modelling the solar cream case study.

Considering the goal of these LCA case-studies, the aim is to assess the environmental hotspots (e.g. Rocca et al., 2023) or to compare the environmental profile of products considering different formulations (e.g. Secchi

et al., 2016). Regarding the chosen functional unit (FU), they are mainly unit-related (n=3) - which are expressed in terms of number of units (e.g. number of cosmetic products) - and mass-related (n=3) ones - which are expressed in terms of kilograms or similar (e.g. 1 kg of product) - while only one study (L'Haridon et al., 2023) uses multiple FUs. However, two of the three mass-related FUs are defined as the quantity of one unit of product. Thus, the unit-related FUs emerge as the most suitable one to use for performing an LCA case-study of cosmetic products.

Regarding the system boundaries (SBs), most of the studies use the cradle-to-grave approach (n=5), considering the entire life cycle of cosmetic products, while others (n=2) use the cradle-to-gate one, considering only the phases included within the company gates and excluding distribution and subsequent phases. Results highlight that using a cradle-to-grave approach could provide more consistent results of environmental impact related to the products, due to the contribution which could derive from the phases of distribution, use, and end-of-life of cosmetic products. For example, the study of Kröhnert and Stucki (2021) reports that the use phase of a shampoo is the life cycle phase that contributes the most to many impact categories. On the contrary, Tamburic et al. (2023) point out that the manufacturing phase of emulsions is the most contributing in terms of environmental impacts. Another example is the study of Rocca et al. (2023), which exhibits that for a mascara the main critical processes are the raw materials and primary packaging ones. Thus, many differences occur for different cosmetic products' categories. Therefore, despite a cradle-to-grave approach is the most recurring in the sample of this scoping review, the SBs of the LCA must be modelled according to the goal of the study and to the specific product which represents the object of the study.

Specifically considering the LCI phase, the type of data employed for performing the studies and the related databases are considered. Most of the studies employ only secondary data (n=5), while the remaining ones employ both primary and secondary data (n=2). The search of secondary data is performed using the Ecoinvent database, solely (n=5) or in combination with other databases (n=2). In detail, L'Haridon et al. (2023) employ also the Agribalyse and the WFLDB, while Rocca et al. (2023) employ also the Agri-footprint and the ELCD. Overall, a predominant use of secondary data from the Ecoinvent database emerges. However, complete and reliable inventory data on many cosmetic ingredients, that are chemical substances, are missing (e.g. Secchi et al., 2026). Thus, potential solutions are considered to avoid this lack. For example, Secchi et al. (2016) propose to use inventory data on similar substances in terms of molecular structure, synthesis, manufacturing, or refining processes. The construction of proxy inventory is presented also in other studies (e.g. Krohnert and Stucki, 2021; Tamburic et al., 2023).

Regarding the LCIA phase, SimaPro is the most employed software (n=5). All the studies take into consideration midpoint impact assessment methods. Many impact categories are considered in almost all the studies, regardless of the employed impact assessment methods. Those which receive much attention are climate change, freshwater ecotoxicity, and freshwater eutrophication.

Finally, regarding the interpretation phase, is analysed whether sensitivity analyses are performed in the studies, also considering the reported sensitive parameters. It is interesting to note that 4 out of the 7 studies

report a sensitivity analysis, but none of these take raw material production into consideration as a sensitive parameter despite the recurring critical issue reported on the lack of inventory data for the production of many substances used in the formulation of cosmetic products. For example, the study of Secchi et al. (2016), which proposes the use of proxy inventory data, then performs two sensitivity analysis but only considering the assumptions on transport and irrigation of olive trees (from which a bio-based ingredient is obtained for the day face cream object of the study), and the application of different LCIA methods as sensitive parameters. Another example is the study of Tamburic et al. (2023), which propose the use of inventory data on substances similar to ones used in the formulation of the analysed cosmetic product (due to the lack of inventory data for the production of these used substances), but then do not perform any sensitivity analysis investigating further about these substitutions.

This scoping review allows the identification of the main characteristics and criticalities of methodological aspects of LCA case-studies of cosmetic products. Thus, the LCA case-study performed in this study is carried out considering the results obtained from the scoping review. In particular, the main methodological choices deriving from the scoping review results and the proposed solutions are summarized in Figure 3.

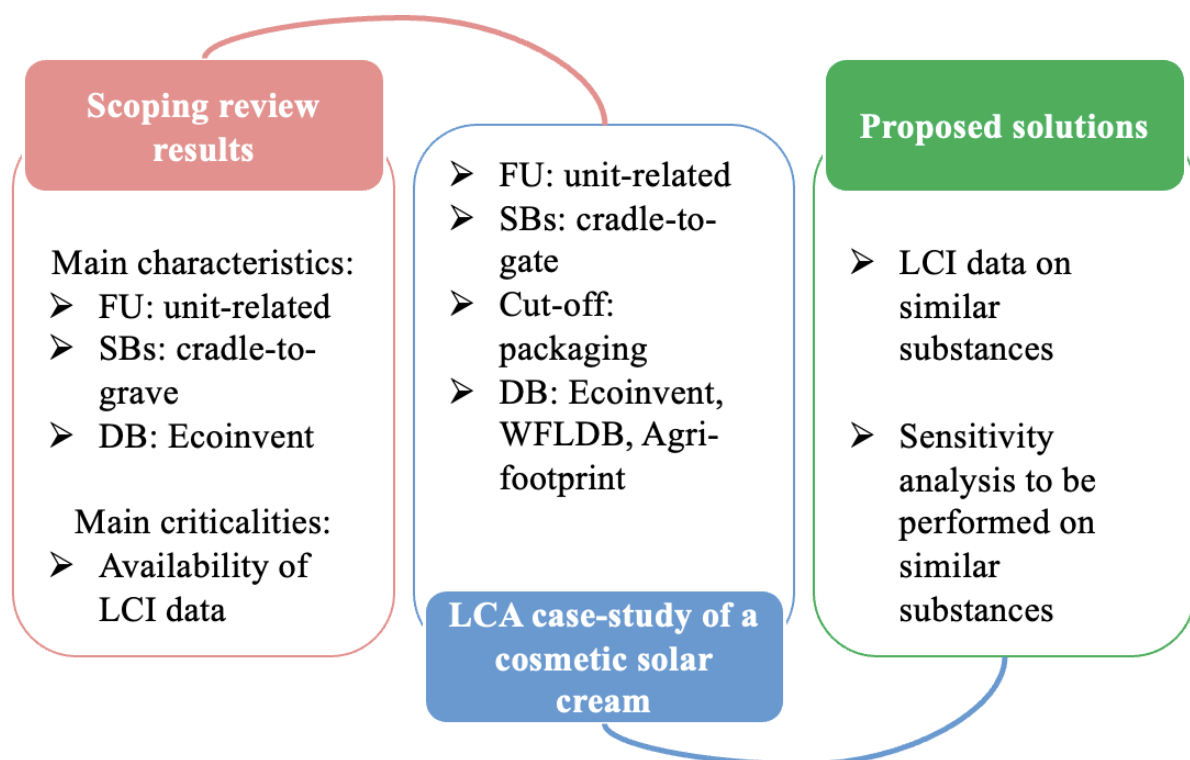


Figure 3. Overview of scoping review results, methodological choices of LCA case-study, and proposed solutions.

The LCA case-study performed in this study has a cosmetic solar cream as object of the analysis. In details, a unit-related FU is defined as “1 cosmetic solar cream”, with reference flow of “1 bottle of 198 g containing 200 ml of solar cream”, which expresses the quantity of product necessary to satisfy the function of the product system. This choice is due to the fact that the unit-related FUs emerge as the most suitable for conducting LCA case-studies of cosmetic products (e.g. Rocca et al., 2023; Kröhnert and Stucki, 2021). Then, despite the cradle-to-grave SBs approach emerges as the most used for LCA case-studies of cosmetic products, in this study a cradle-to-gate approach is employed. Indeed, due to the aim of this study, which is of verifying the availability of inventory data concerning the cosmetic ingredients, only the phases of sourcing of raw materials and manufacturing of the product are considered, while the packaging phase is excluded (see Methodology paragraph and Figure 2).

The LCI phase is performed starting from primary data collection. A total of 18 ingredients are identified, which are composed by one or more substances. The included substances are a total of 28, for all of which secondary data are searched in the above cited databases. Table 1 reports how the LCI of this case-study is constructed, showing databases from which inventory data are collected. In addition, the level of match between International Nomenclature Cosmetic Ingredients (INCI) name of substances and the related processes found in databases is reported according to the following classification: level 1, green colour, when inventory data for a substance are available in the databases; level 2, orange colour, when inventory data on similar substances are employed; level 3, red colour, when no data on the substance or similar ones are found either, thus data on generic organic or inorganic chemical production processes are used. For the similar substances, choices are based on similarity of chemical structure or manufacturing processes. When the choice is made according to findings of other studies, the reference is reported in Table 1. When the related processes of substances are found in the database, the reference is not reported due it is the database itself. Finally, when a similar process is chosen by the authors of this study, no other references are reported.

Table 1. Life Cycle Inventory data for cosmetic solar cream

INCI name	Process name	Level of match	Databases	Choice also made in (Reference)
Amber extract	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Ascorbyl palmitate	Ascorbic acid, RER, ascorbic acid production, cut-off, U	2	Ecoinvent	
Benzyl Alcohol	Benzyl alcohol, RER, benzyl alcohol production, cut-off, U	1	Ecoinvent	
Butyl methoxydibenzoylmethane	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
C12-C15 Alkyl benzoate	Chemical, organic, GLO, chemical	3	Ecoinvent	

	production, organic, cut-off, U			
Caprylic/capric triglyceride	Caprylic-capric acid (C8-C10) from coconut oil fractionation, at plant (WFLDB)/GLO U	2	WFLDB	
Caprylyl/capryl glucoside	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Cetearyl isononanoate	Fatty alcohol production from coconut oil, ref	2	Ecoinvent	Tamburic et al. (2023)
Citric acid	Citric acid, RER, production, cut-off, U	1	Ecoinvent	
Deionised water	Water, deionised, Europe without Switzerzland, water production, deionised, cut-off, U	1	Ecoinvent	
Disodium EDTA	EDTA, ethylenediaminetetraacetic acid, RER, EDTA production, cut-off, U	2	Ecoinvent	
Ethylhexyl triazone	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Ethylhexylglycerin	Glycerine, RER, production, from epichlorohydrin, cut-off, U	2	Ecoinvent	
Glycerin	Glycerine, RER, production, from epichlorohydrin, cut-off, U	1	Ecoinvent	
Helianthus annuus seed oil	Crude sunflower oil, from crushing (solvent), at plant, IT mass	2	Agri-footprint	
Lauryl glucoside	Glycerine, GLO, stearic acid production, cut-off, U	2	Ecoinvent	
Lecithin	Soybean lecithin, from crushing (solvent), at plant, IT mass	1	Agri-footprint	
Leuconostoc/radish root ferment filtrate	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Magnesium aluminium silicate	Sodium silicate, without water, in 37% solution state, RER, sodium silicate production, furnace liquor, product in 37% solution state, cut-off, U	2	Ecoinvent	
Octocrylene	Benzyl chloride, RER, benzyl chloride production, cut-off, U	2	Ecoinvent	Secchi et al. (2016)
Phenoxyethanol	Esterification of soybean oil, RoW, glycerine	2	Ecoinvent	Tamburic et al. (2023)

Polyglyceryl-2 dipolyhydroxystearate	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Raphanus sativus seed extract	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Rosmarinus officinalis leaf extract	Chemical, organic, GLO, chemical production, organic, cut-off, U	3	Ecoinvent	
Sodium lauryl glucose carboxylate	Polycarboxylates, 40% active substance, RER, production, cut-off, U	2	Ecoinvent	
Tocopherol	Cottonseed oil, refined, RoW, cottonseed oil refinery operation, cut-off, U	2	Ecoinvent	Tamburic et al. (2023)
Tocopherol acetate	Cottonseed oil, refined, RoW, cottonseed oil refinery operation, cut-off, U	2	Ecoinvent	
Xanthan gum	Guar gum at plant (WFLDB)/IN U	2	WFLDB	

It has to be noted that inventory data of only 5 out of the 28 substances are found, of which 4 are provided from Ecoinvent and 1 from Agri-footprint database. Inventory data for other 14 substances are found using similar ones, which are provided from the Ecoinvent database, except 2 from WFLDB and 1 from Agri-footprint. For the remaining 9 substances, inventory data regarding the productive process of organic chemical substances are selected from Ecoinvent. As already highlighted in the results of the scoping review, Ecoinvent emerges as the most complete database of data for cosmetic products also in the case study. Indeed, inventory data of a total of 25 out of the 28 substances of the cosmetic solar cream are collected from Ecoinvent.

Overall, the problem of missing data for cosmetic ingredients emerges from both the scoping review and the case-study of the cosmetic solar cream. However, the implications which arise from this issue are not well discussed in the sample of the scoping review. Few studies only report that the missing of data on raw materials is a limitation of the LCA study (Tamburic et al., 2023) and that the use of proxy processes could influence the robustness of LCA results obtaining underestimate impacts (Secchi et al., 2016).

This issue is also reported in the Product Category Rules (PCR) of cosmetics (soap, perfume and toilet preparations) (PCR, 2024). The PCR state that specific data should be preferred, but the use of proxy data is permitted when specific ones are not available for the background processes. In addition, specifically referring to chemicals, the PCR suggests the use of stoichiometry for the modelling of chemical processes (PCR, 2024). However, this option could further complicate the LCA study making it even more time and resource spending, considering that the use of stoichiometry for the modelling of chemical processes requires the involvement of chemistry experts.

Indeed, the missing of specific data represents an important issue for which solutions must be found, especially if concerning the core process of a system, which in the case-study presented in this study is represented by the manufacturing process. Another potential solution to avoid the use of proxy data is implicitly proposed by the four Environmental Product Declaration (EPD) which are available for some cosmetic products (EPD, 2024a; EPD, 2024b; EPD, 2024c; EPD, 2024d). In these declarations, the LCI of the products is based on generic substances selected by their function (e.g. emollients, antioxidants, etc.). However, also this potential solution may decrease the reliability of studies in the sector, due to the poor specificity of the data.

Despite that, the use of proxy inventory data is the most used solution for performing a LCA case-study of cosmetic products avoiding the lack of specific data for many cosmetic ingredients (Tamburic et al., 2023; Secchi et al., 2016). Thus, the modelling of the case-study here presented is based on the findings of the scoping review and proxy data are used. Further research is needed to verify the reliability of results. For example, a sensitivity analysis should be performed considering the inventory data.

Conclusions

This study firstly aims to identify the methodological choices of LCA case-studies of cosmetic products by performing a scoping review. Secondly, a LCA case-study of a cosmetic solar cream is performed with the aim of verifying the availability of LCI data due to related criticalities that emerged in literature.

The scoping review is carried out on a sample of 7 studies, which have different cosmetic products as object of analysis. Unit- or mass-related FUs are mostly employed in the studies, which mainly adopt a cradle-to-grave approach for defining the system boundaries of the study. Primary data and secondary data are employed for the construction of LCI in almost all the studies (n=5), while the remaining ones employ only secondary data. However, a lack of complete and reliable inventory data on cosmetic ingredients is highlighted. Most of the studies report the use of the SimaPro software and all of them take into consideration midpoint impact assessment methods. Finally, just over half of the sample reports sensitivity analyses aimed to test the robustness of results. However, no study has performed sensitivity analyses considering inventory data as a sensitive parameter.

According to the results of the scoping review, the case-study of a cosmetic solar cream is carried out. A unit-related FU is defined as 1 cosmetic solar cream. A cradle-to-gate approach is employed due to the aim of the study of verifying the availability of inventory data for cosmetic ingredients. Thus, the analysis focuses on the sourcing and manufacturing life cycle phases of the product.

Primary data are collected from the productive plant of the cream, which is located in Central Italy. This step allows the identification of 18 ingredients, which are composed by a total of 28 substances. Inventory data are searched for each of the substance in some of the most known and used databases, i.e. Ecoinvent, Agri-footprint, WFLDB, ELCD, and USLCI, using the SimaPro software.

Inventory data are found for only 5 substances, of which 4 from Ecoinvent and 1 from Agrifootprint database. For the remaining substances, inventory data on similar ones (n=14) or on the generic process of organic chemicals production (n=9) are employed mainly from the Ecoinvent database.

Overall, the critical issues related to the availability of inventory data for cosmetic ingredients are confirmed by the results of this case-study. In addition, the Ecoinvent database emerges as the most suitable for conducting the LCI phase of LCA studies of cosmetic products, as already reported in literature. In fact, although the data for most of the substances of the product that is the object of this analysis are not available, Ecoinvent is the most used database to find data for alternative but similar substances.

However, the LCI obtained in this analysis implies some limitations. The use of inventory data on similar substances or on generic processes could influence the impact assessment results. Consequently, sensitivity analysis should be carried out for verifying the potential change in results that derives from the use of inventory data of one substance rather than another. Thus, further research will be oriented to perform a sensitivity analysis on inventory data with the aim of checking the robustness of results based on LCI data on similar substances.

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