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THE UNIQUE HIGH-PERFORMANCE BIODEGRADABLE LEATHER TANNED WITH NATURAL ELEMENTS*

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Abstract

Sustainability has today assumed a centrality in the fashion industry. Santori Pellami SpA is an Italian company founded in 1890 and specialised in the production and sale of animal leathers. Since 2015 Santori has been in the search for more sustainable materials, to obtain a leather product that could meet the needs of a transforming market. Indeed, today we observe consumer trends, new technologies and innovative business models helping to lead the future of fashion towards a more sustainable runway. In 2017 Santori has developed an innovative process to obtain a high-quality leather, named Naturella®, Chromium free, with low use of heavy metals and biodegradable. In 2018 Santori has received funding from the European Union's Horizon 2020 research and innovation programme to develop a Technical and Economic Feasibility of an innovative "short-chain" business model for Naturella® in the main European markets. In 2018 Santori filed the national Patent application N.102018000008252 - "Improved metal-free tanning process" for Naturella® and in May 2019 Santori received the Search Report and Written Opinion from the Ufficio Italiano Brevetti e Marchi, in which it is said that "the matter-subject is regarded as novel". A Life Cycle Assessment in compliance with European PEFCR and a Durability Analysis have been carried out, in collaboration with Politecnico di Milano, Innovhub – Stazioni Sperimentali per l'Industria and Larix Italia. Through LCA the full list of impact categories in the common context of the European Market for Green Products has been evaluated.

Keywords: biodegradability, environmental impact, fashion industry, leather, life cycle assessment, product environmental footprint, tanning industry, sustainability

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1. Introduction

Today, the theme of environmental sustainability in the leather sector is tremendously increased, due to the pressing demand of all operators of the fashion industry for eco-friendly materials, pushed by the environmental regulations and the growing market demand for green products. In particular, in the leather sector the traditional tanning process that converts the protein of the raw hide into a stable material which will not putrefy, has high environmental and human health impacts, due to:

- the heavy use of polluting chemicals and metals: the most commonly used tanning material is hexavalent Chromium. Chemicals are also azo dyes, free formaldehyde, pentachlorophenol, tetra chlorophenols; other metals that are extractable with human sweat are nickel, cadmium, cobalt and lead;
- air pollution due to the transformation process, producing hydrogen sulphide during dehairing and ammonia during deliming, and solvent vapours.

Therefore, the traditional tanning process causes ecological imbalance and the spreading of different kinds of serious and contagious disease among the tannery workers and other individuals involved in the process. When inhaled, Chromium acts as a lung irritant and carcinogen, affecting the upper respiratory tract and obstructing airways. In addition, tanning 1 ton of hide typically results in 20 to 80 cubic meters of waste water with Chromium concentrations around 250 mg/L, and sulphide concentrations at roughly 500 mg/L (Borrely et al., 2018). It is therefore urgent to turn towards leather products and processing methodologies more sustainable and safer for the operators' and people health.

Naturella® leather is the answer to the compelling needs of the fashion industry for environmental sustainability and is a brand-new alternative business model throughout the leather tanning value chain. Actually, this innovative process is able to obtain a unique certified biodegradable leather according to ISO 14855 (UNIBO, 2017), in which high quality hides are tanned using biodegradable, organic elements and without dangerous heavy metals like Chromium. The hides have been tested and passed standard requirements for abrasion resistance, colour fastness, grab strength, and dry and wet crocking for footwear and fashion needs. Indeed, Naturella® can be used in the fashion industry for footwear and accessories as first market and for clothing as secondary market.

Santori's business model, based on patent protection and licensing to certified production partners, aims to spread our innovation not only at European level, but also in non-European countries, where damages from environmental pollution can threaten a large number of people. The model Santori has chosen for their value chain is that of "short-chain", maximising the environmental sustainability of their products.

Naturella® responds to the pressing need of greening the leather manufacturing process, coherently with the UN Sustainable Development Goal Number 12 - Ensure sustainable consumption and production patterns, aimed to reduce environmental impact of any human activity. In addition, it responds to the increasing demand of an exigent market, increasingly driven by environment-friendly products while maintaining the highest quality and performance levels.

The main objective of this project has been to fully evaluate all the environmental impacts of metal-free and biodegradable Naturella® leather, in accordance to the PEFCR – Product Environmental Footprint Category Rules for the production of leather, published in April 2018 on behalf of the European Commission's Joint Research Centre (De Rosa-Giglio et al., 2018).

Another objective has been to carry out the analysis of durability for Naturella® (Innovhub, 2019), assessing:

- the physical-mechanical characteristics of the leather (maximum strength and stretching with traction according to UNI EN ISO 13934-1:2013, i.e. stress test, colour and temperature resistance test);
- the resistance of the leather to mildew, fungii and bacteria (according to AATCC 30/2013);
- the soil burial test according to AATCC 30;
- aging due to temperature, humidity, light.

This work is divided in two main parts:

- evaluation of all the environmental impacts of metal-free and biodegradable Naturella® leather, in accordance to the PEFCR. The evaluation has been performed by Prof. Giovanni Dotelli, full Professor of Materials Science and Technology at Politecnico di Milano;
- analysis of durability. The analysis has been performed by Innovhub-Stazioni Sperimentali per l'Industria, Milan.

2. Materials and methods

Every step of the LCA study has been performed as much in accordance to the PEFCR – Product Environmental Footprint Category Rules for the production of leather, published in April 2018 on behalf of the European Commission's Joint Research Centre.

Naturella® is modelled as bovine leather belonging to the Representative Product category RP2 for footwear and leather goods. A cradle-to-gate approach is followed in the study: upstream (farming, slaughtering and preservation) and core (tanning) processes have been identified within the system boundary. The core process has been divided into eight unit processes where the main production phases of Nature-L® are performed (Fig. 1).

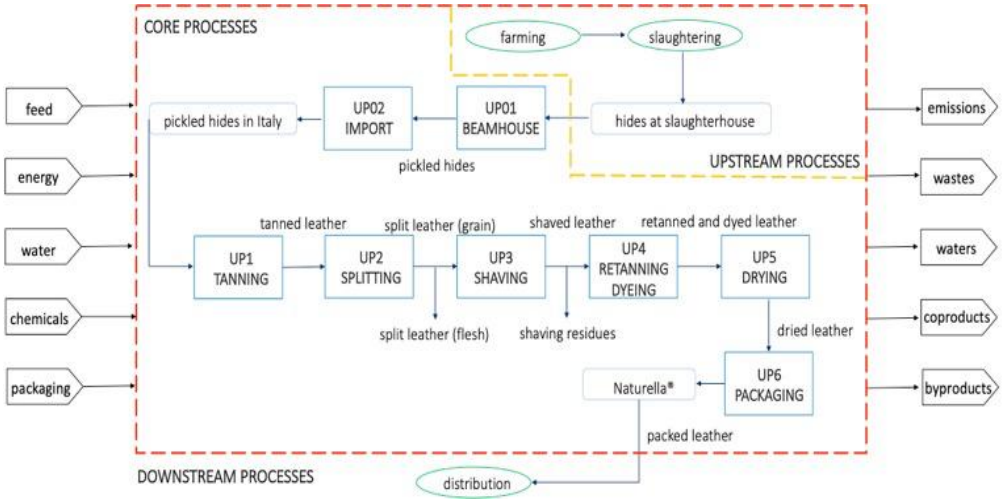


Fig. 1. System boundary for the production of Naturella® with the main unit processes

For every unit process, data about the required material, energetic and logistic input and output flows have been collected and modelled using the PEF-compliant datasets included in the Environmental Footprint EF2.0 database. The obtained information has been processed using the PEF-compliant Environmental Footprint EF2.0 Impact Assessment methods.

The evaluation of the environmental impacts has been mainly based on company-specific data collected from the industrial realities where the leather tanning process for Naturella® is performed.

3. Results and discussion

Following the PEF guidelines, the environmental impact of 1 square metre of Naturella® is quantified through characterization for every PEF-compliant impact category (Table 1).

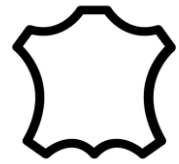
However, the PEF Category Rules for leather don't allow the evaluation of the environmental benefit guaranteed by the biodegradability of the product. It is so since leather is an intermediate product and the PEF-compliant cradle-to-gate approach implies a system boundary ending with the production of leather in the industrial facilities, thus not considering downstream processes as B2B distribution, further manufacturing into finished consumer products, distribution to customers, use phase and end-of-life treatment of used products (Fig. 2).

Table 1. Results of the PEF- compliant characterization step

Impact category	*Unit of measure*	*Total*
Climate change	kg CO2 eq	4.15E+01
fossil		1.72E+01
biogenic		1.56E+01
land use and transformation		8.75E+00
Ozone depletion	kg CFC11 eq	1.86E-07
Ionising radiation, HH	kBq U-235 eq	6.72E-01
Photochemical ozone formation, HH	kg NMVOC eq	6.41E-02
Respiratory inorganics	disease incidence	4.15E-06
Non-cancer human health effects	CTUh	3.11E-05
Cancer human health effects	CTUh	6.48E-07
Acidification terrestrial and freshwater	mol H + eq	5.48E-01
Eutrophication freshwater	kg P eq	4.73E-03
Eutrophication marine	kg N eq	1.54E-01
Eutrophication terrestrial	mol N eq	2.32E+00
Ecotoxicity freshwater	CTUe	1.20E+02
Land use	Pt	3.70E+03
Water scarcity	m3 deprived	2.22E+01
Resource use, energy carriers	MJ	1.73E+02
Resource use, minerals and metals	kg Sb eq	6.33E-05

Wheat bread, 250 g
0.21 $kgCO_{2eq}$

Beef fillet, 150 g
6.72 $kgCO_{2eq}$



Naturella®, 1 m^2
41.50 $kgCO_{2eq}$

Fig. 2. Climate change impact comparison (http://lcafood.dk)

The climate change category presented in this study indicates the GWP – Global Warming Potential of the analysed process in terms of fossil, biogenic and land use/transformation contributions. It is expressed in kg CO_2 eq and it's a good measure of the Carbon Footprint of Naturella®, indicating the quantity of GHG – Green House Gases emitted during the production.

Non-cancer and cancer human health effects belong to toxicity categories, expressed in the study in Comparative Toxic Unit for human (CTUh). This unit indicates the estimated increase in morbidity in the total human population per unit mass of the chemicals emitted.

Ecotoxicity freshwater indicates the impact of the studied production process in terms of toxicity in the environmental matrix of freshwaters. It's expressed in Comparative Toxic Unit for human (CTUh).

Land use is expressed in dimensionless points. This impact category is related to the soil quality index. Water scarcity is a measure of the user deprivation potential in terms of relative available blue water remaining. It is expressed therefore as cubic meters of water deprived by the studied processes.

Normalization and weighting are optional Impact Assessment steps; both have been performed using PEF- compliant factors (Fig. 3).

Normalization is the calculation of the magnitude of each category indicator with respect to the global impact per person considering the world's population.

Weighting is used to create a single score value by correlating every impact assessment result with a set of factors that reflect the perceived relative importance of the impact categories.

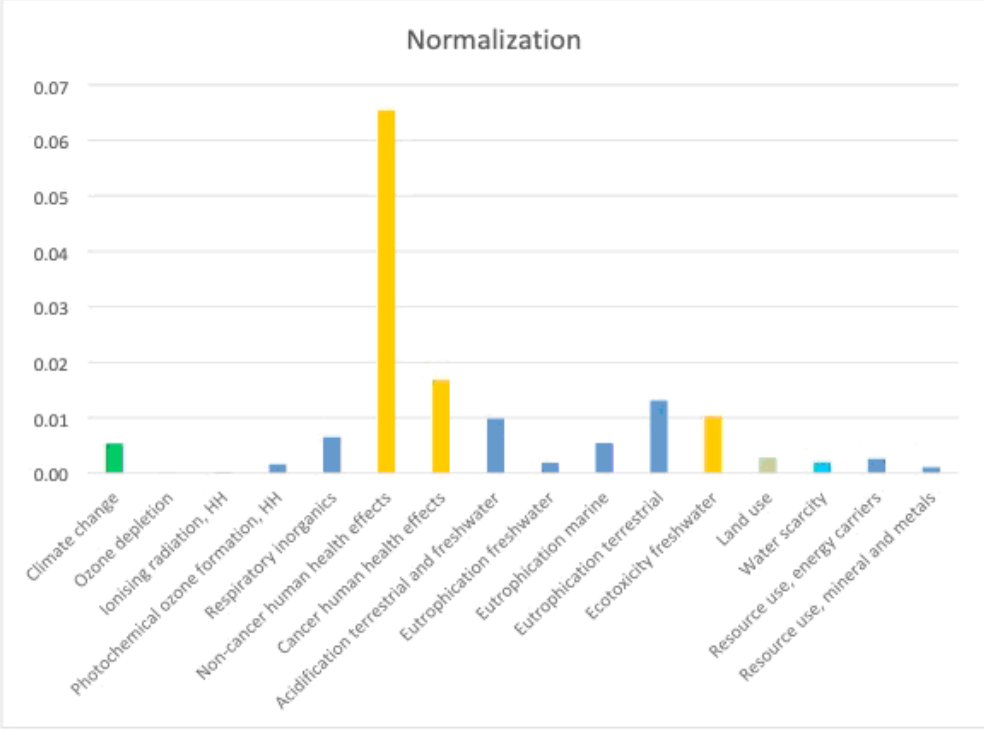


Fig. 3. Results of the PEF-compliant normalization step

After normalization, the most relevant impact categories are the toxicity ones, represented by "Non-cancer human health effects", "Cancer human health effects", "Eutrophication terrestrial" and "Ecotoxicity freshwater".

The most relevant impact categories included in the PEF Category Rules document (as acidification, climate change, terrestrial eutrophication, particulate matter, resource use – fossils and water use) present little normalized contribution for the production of Naturella®.

The process has been divided into the PEF-compliant sections of upstream and core (Table 2).

Farming, slaughtering and preservation are upstream processes and contribute to the majority of the impacts (Table 3 and Fig. 4).

Thanks to the specific recipe used in the production process of Naturella® leather, the core tanning process presents lower impact than the upstream one (Fig. 5).

Table 2. The PEF-compliant sections

	Upstream %	***Core***
Weighting single score	91.60	8.40

Table 3. Relative contribution to the characterization and single score weighting results for core and upstream processes

	Upstream %	***Core %***
Climate change	89.01	10.99
Non-cancer human health effects	97.34	2.66
Cancer human health effects	91.12	8.88
Ecotoxicity freshwater	92.87	7.13
Land use	95.45	4.55
Water scarcity	71.11	28.89

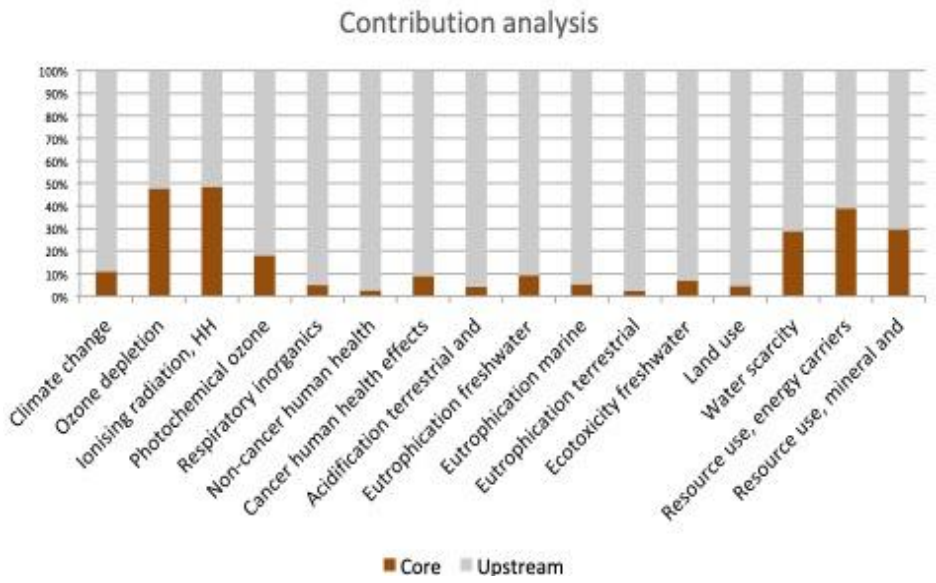


Fig. 4. Results of the PEF-compliant contribution analysis

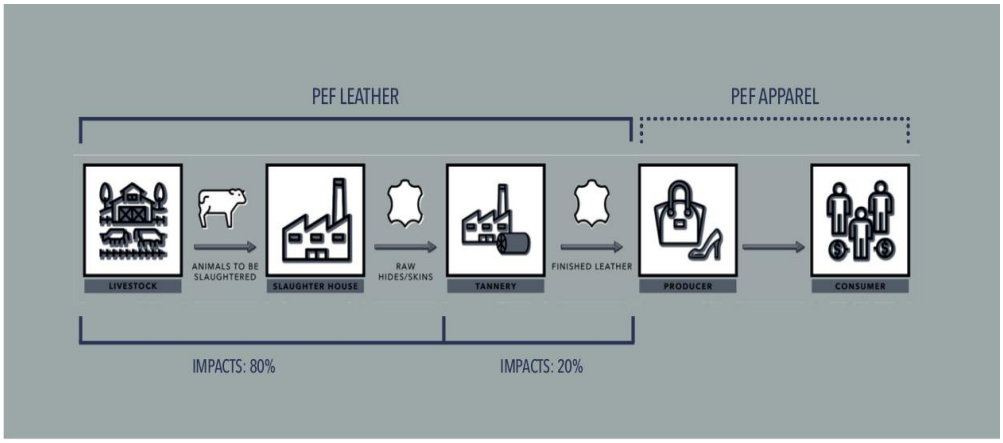


Fig. 5. Results of the PEF-compliant: impact on core and upstream processes

4. Concluding remarks

From the data obtained, farming, slaughtering and preservation phases in the production of raw hides and skins have a higher environmental impact than the core tanning process for the production of Naturella®: 91.6% of the impacts for Naturella® come from the upstream processes, while tanning activities occurring in Italy accounts for 8.4% of the total environmental burden.

Santori Pellami through its metals-free biodegradable leather products contributes actively to support Sustainable Development Goals (SDG): 12 (Responsible consumption and production), 13 (Climate action), and 15 (Life on Land).

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