Discussion on key issues of carbon footprint quantification of silk products

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LIU CAN
LI QIZHENG
LIU SHUYI
LI XIN
ZHANG YING
WANG LAILI

ABSTRACT – REZUMAT

Discussion on key issues of carbon footprint quantification of silk products

In this study, to accurately calculate the carbon footprint of silk products, key issues were analysed and discussed, including accounting boundary, accounting data, sequestration of greenhouse gases (GHG) and calculation of results. The results support the feasibility of "cradle to gate" or "gate to gate" as the accounting boundary for the carbon footprint of silk products. Accordingly, the quality of accounting data may be improved by determining the key emission sources of GHG within the accounting boundary, selecting the appropriate data allocation methods and maintaining the consistency of the allocation methods within the accounting boundary when necessary. The GHG sequestration of silk is explained separately in the results, which report on the carbon footprint of silk products. The carbon-neutral actions taken by silk enterprises are also discussed and quantified in the results of the carbon footprint calculation. Ultimately, it is found that a consistent accounting boundary and emission factors constitute two key prerequisites for the feasibility of carbon footprint quantification of various silk products.

Keywords: *silk products, carbon footprint, accounting boundary, carbon neutralization, allocation*

Discuții privind problemele cheie de cuantificare a amprentei de carbon a produselor din mătase

În acest studiu, pentru a calcula cu exactitate amprenta de carbon a produselor din mătase, au fost analizate și discutate aspecte cheie, inclusiv limitele contabile, datele contabile, captarea gazelor cu efect de seră (GES) și calculul rezultatelor. Rezultatele susțin fezabilitatea „de la producţie până la livrare“, ca limită contabilă pentru amprenta de carbon a produselor din mătase. În consecință, calitatea datelor contabile poate fi îmbunătățită prin determinarea surselor cheie de emisie a GES în limitele contabile, selectând metodele adecvate de alocare a datelor și menținând consistența metodelor de alocare în limitele contabile, atunci când este necesar. Captarea GES din mătase este explicată separat în rezultate, care raportează amprenta de carbon a produselor din mătase. Acțiunile neutre în ceea ce priveşte carbonul întreprinse de companiile producătoare de mătase sunt, de asemenea, discutate și cuantificate în rezultatele calculului amprentei de carbon. În cele din urmă, se constată că o limită contabilă consecventă și factorii de emisie constituie două premise cheie pentru fezabilitatea cuantificării amprentei de carbon a diferitelor produse din mătase.

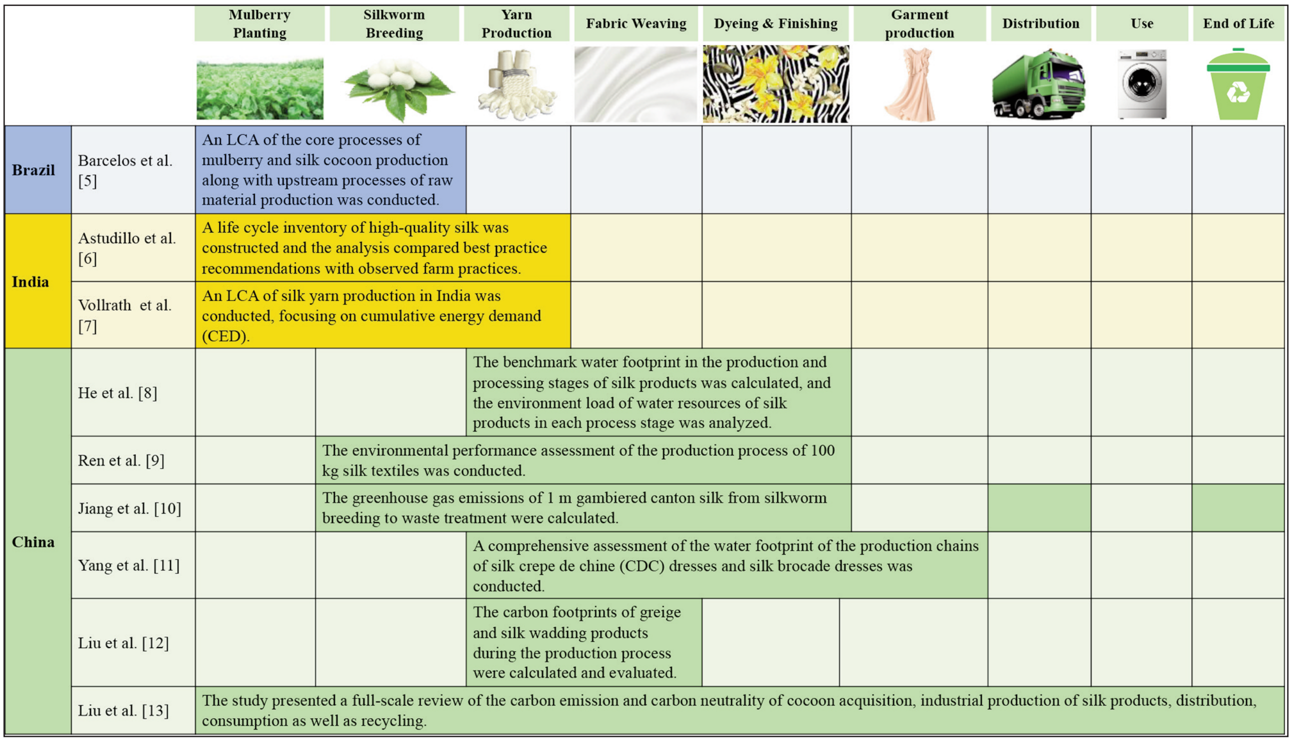
Cuvinte-cheie: *produse din mătase, amprentă de carbon, limită contabilă, neutralizarea carbonului, alocare*

INTRODUCTION

In China, industrial green low-carbon development and consumption of green and low-carbon products constitute key elements of the carbon peaking and carbon neutrality goals. The calculation of the carbon footprint of products throughout their life cycle provides an important reference conducive to carbon mitigation in industrial production and progress concerning consumption. In this regard, in China, the Ministry of Industry and Information Technology published the 14th Five-Year Plan for Green Development of the Industry Sector, which has listed the calculation of the carbon footprint of products among the main tasks assigned to green development in the industry. Moreover, the Implementation Plan for Promoting Green Consumption has set exploring and establishing the standards of the carbon footprint of key products over the whole life cycle as a priority.

Around 2005, discussions commenced concerning the concept and calculation methods of a carbon footprint. At the outset, Carbon Trust published Carbon Footprint Measurement Methodology Version 1.1 in 2007, after which, several institutions, including the British Standards Institution (BSI), the International Organization for Standardization (ISO), the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) have promoted the enactment of carbon footprint accounting standards [1, 2]. In addition, in 2008, BSI published "PAS 2050:2008 Specification for the Assessment of the Life Cycle Greenhouse Gas Emissions of Goods and Services"; in 2011, an updated version was released. In 2011, WRI and WBCSD co-published "GHG Protocol: Product life cycle accounting and reporting standard". While the carbon footprint of products was not explicitly identified in this document, general requirements for the quantification of the life cycle of emission of greenhouse gases were set out, and conditions for evaluation and reporting were stipulated in general terms. Published by ISO in 2013, "ISO/TS 14067:2013 Greenhouse Gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification and Communication", defined the concept of the carbon footprint of a product (CFP) and stipulated requirements of boundary setting for the CFP, in addition to accounting data inventory and accounting methods; to establish international standards, this document was subsequently updated to ISO 14067:2018. When calculating, evaluating and reporting the carbon footprint of silk products in the life cycle based on the above three general standards and technical specifications, accounting personnel frequently demonstrate varying understandings about key elements of carbon footprint accounting, including boundary setting, data collection and allocation methods, leading to high uncertainty and poor comparability of accounting results [3]. Published by BSI in 2014, "PAS 2395:2014 Specification for the Assessment of Greenhouse Gas (GHG) Emissions from the Whole Life Cycle of Textile Products", and T/CNTAC 11-2018 "General requirements for Quantifying Greenhouse Gas Emissions of Textile Products", specified the transformation of international general standards and technical specifications about the textile industry. Meanwhile, in both China and around the world, several institutions are at work developing Product Category Rules (PCR) for carbon footprint accounting in the interest of standardizing the accounting of the CFP in detail. Meanwhile, China's textile industry standards have been in the process of formulation, as demonstrated by such documents as the following: "Carbon Footprint of a Product: Product Type Rules for Textile Products", "Carbon Footprint of a Product: Product Type Rules for Woolen Yarn", "Carbon Footprint of a Product: Product Type Rules for Woolen Fabric" and "Carbon Footprint of a Product: Product Type Rules for Woolen Knitted Products".

Due to their high quality, silk products constitute a popular textile product category among consumers. The production of cocoons and raw silk in China accounts for more than 80% of global production [4], and China ranks first in the world in the production and processing of silk fabrics, silk garments, and silk home textiles. Therefore, the carbon footprint of silk products is of great significance for the sustainable development of the silk industry. At present, studies on the environmental performance of silk products throughout their life cycle largely focus on cocoons, raw silk, silk fabrics, silk garments, and other craft products, as shown in figure 1. For example, Barcelos et al. [5] conducted a life cycle assessment of the core processes of mulberry and silk cocoon production along with upstream processes of raw material production. Accordingly, the number of opportunities for improving the environmental profile of mulberry and silk cocoon production under Brazilian conditions was determined. Additionally, in southern India, Astudillo et al. [6] constructed a life cycle inventory of the production of high-quality silk and compared best practice recommendations with observed farm practices. The results demonstrated that GWP_{100} values of 1 kg raw silk under farm practices and recommended practices were 80.9 kg CO_2eq/kg and 52.5 kg CO_2eq/kg respectively. Also in India, Vollrath et al. [7] conducted an LCA of silk yarn production, focusing on cumulative energy demand



		Mulberry Planting	Silkworm Breeding	Yarn Production	Fabric Weaving	Dyeing & Finishing	Garment production	Distribution	Use	End of Life
Brazil	Barcelos et al. [5]	An LCA of the core processes of mulberry and silk cocoon production along with upstream processes of raw material production was conducted.								
India	Astudillo et al. [6]	A life cycle inventory of high-quality silk was constructed and the analysis compared best practice recommendations with observed farm practices.								
	Vollrath et al. [7]	An LCA of silk yarn production in India was conducted, focusing on cumulative energy demand (CED).								
China	He et al. [8]			The benchmark water footprint in the production and processing stages of silk products was calculated, and the environment load of water resources of silk products in each process stage was analyzed.						
	Ren et al. [9]		The environmental performance assessment of the production process of 100 kg silk textiles was conducted.							
	Jiang et al. [10]		The greenhouse gas emissions of 1 m gambiered canton silk from silkworm breeding to waste treatment were calculated.							
	Yang et al. [11]			A comprehensive assessment of the water footprint of the production chains of silk crepe de chine (CDC) dresses and silk brocade dresses was conducted.						
	Liu et al. [12]			The carbon footprints of greige and silk wadding products during the production process were calculated and evaluated.						
	Liu et al. [13]	The study presented a full-scale review of the carbon emission and carbon neutrality of cocoon acquisition, industrial production of silk products, distribution, consumption as well as recycling.								

Fig. 1. Literature review on life cycle assessment of silk products

(CED), rendering calculated CED values above 1800 MJ/kg. In China, He et al. [8] calculated and assessed the benchmark water footprint in the production and processing stages of silk products. The results demonstrated that the benchmark water discharge footprint of the silk reeling stage, dyeing stage, and weaving stage was 682.7 m^3 H_2O eq/t, 297 m^3 H_2O eq/t and 252.5 m^3 H_2O eq/t. Ren et al. [9] conducted an environmental performance assessment of the production process of 100 kg silk textiles, and the calculated GWP value came to 20.253 kg CO_2 in total. Meanwhile, Jiang et al. [10] calculated the greenhouse gas emissions of 1 m gambier canton silk, delivering a result of 1.88 kg CO_2e/m. On top of these, Yang et al. [11] conducted a comprehensive assessment of the water footprint of the production chains of silk crepe de chine (CDC) dresses and silk brocade dresses utilizing the ISO 14046 and the life cycle assessment polygon method. Similarly, Liu et al. [12] calculated and evaluated the carbon footprint results of greige and silk wadding products during the production process, turning out that the carbon footprints of greige products made from fresh cocoons and dry cocoons were 24.93 kg CO_2e/kg and 27.84 kg CO_2e/kg respectively, and the CF result of silk wadding product was 10.14 kg CO_2e/kg. On the whole, Liu et al. [13] reviewed the research progress in terms of the environmental performance assessment of silk products, reflecting upon and reconsidering the research methods, calculation boundary, data inventory and result evaluation. Notwithstanding, the life cycle chains of various silk products prove long and complicated, involving a great many contributory and productive elements. Accordingly, the key issues of the carbon footprint of silk products need to be fully analysed. Nevertheless, few studies have systematically analysed the standards relating to accounting as pertains to the carbon footprint produced during the life cycle of silk products. Accordingly, this work discusses and makes recommendations regarding key issues in the quantification of the carbon footprint of silk products, including boundary setting, data collection and distribution, and result in acquirement.

Specifically, this study provides references and suggestions for evaluating the accounting of the carbon footprint of silk products and the development of related standards.

ACCOUNTING BOUNDARY

The carbon footprint of a product constitutes the quantification of global climate change in the life cycle of a product; thus the accounting of the carbon footprint requires an assessment of the entire life cycle of the product [14]. As such, the entire life cycle of silk products may be divided into five stages, namely the acquisition of silkworm cocoons, the manufacturing, the sales and use of products, the disposal of products, as well as recycling. In turn, each stage is divided into several segments. The initial stage, that of silk cocoon acquisition, essentially pertains to silkworm breeding. Depending on the species of silkworm, the breeding methods include traditional mulberry silkworm breeding, sericulture breeding, factory mulberry silkworm breeding, etc.

Subsequently, the manufacturing stage includes reeling, weaving, whitening, dyeing, printing, sewing and so on. In addition, the sales and use stage encompasses trade and retail, laundry care, etc. Finally, the disposal stage represents the terminus of the life cycle of silk products, while the recycling stage constitutes the beginning of the life cycle of recycled silk products.

According to the definition of the carbon footprint of a product in ISO 14067:2018, the carbon footprint represents a quantification of the impact on climate change resulting from the sum of greenhouse gas emissions and sequestration over the full or partial life cycle of a product (one or more life cycle segments). The accounting boundaries of a partial CFP vary by circumstances, including “cradle to grave”, “cradle to gate” and “gate to gate”. To set a specific accounting boundary is to determine the range of carbon footprint quantification. The selected boundary directly affects the involved inputs and outputs, which in turn affects the GHG assessment results of the target product [15]. Multiple types of by-products may be generated during the whole life cycle process of silk products (such as white silk, silk fabrics and silk apparel). If the entire life cycle assessment is conducted, accounting for the carbon footprint is usually impracticable due to the uncertainty of the subsequent applications of by-products. For example, white silk may be used to produce dyed fabrics and then to create silk garments, or be used to produce printed fabrics and then silk scarves. As a consequence, it is practical to select “cradle to gate” or “gate to gate” as the accounting boundary of the carbon footprint of silk products. When the specifics of distribution, use, disposal and recycling are confirmed, including the modes of transport, distance from factory to retail store, whether sales are to be online or offline, methods and frequency of laundry, methods of disposal (landfill or incineration), and recycling, it becomes feasible to set “cradle to grave” as the accounting boundary for calculating the carbon footprint of silk products over the whole life cycle. The boundary of “cradle to gate” and “gate to gate” can be adjusted flexibly, based upon the accounting purpose of the carbon footprint of silk products, as shown in figure 2. The process of “cradle to gate” can start with silk eggs and proceed to different product stages, such as silkworm cocoons, white silk and silk fabrics. The progress of “gate to gate” may commence from silkworm cocoons and extend to white silk or silk fabrics. On the other hand, it can also start from white silk to silk fabrics or silk apparel. Although the setting of an accounting boundary for the carbon footprint of silk products is highly flexible, the selected accounting boundary should be explained clearly when reporting the carbon footprint accounting results and comparing the carbon footprint of specific products. The prerequisite for the accounting carbon

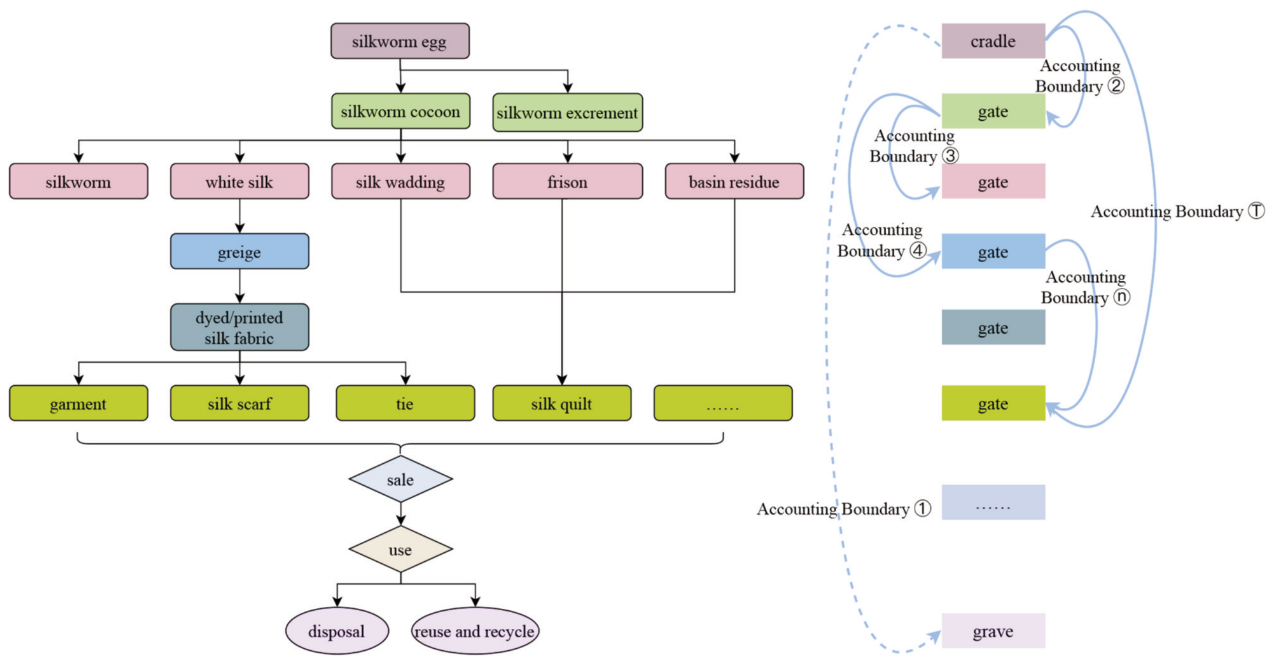


Fig. 2. Accounting boundary of the carbon footprint of silk products

footprint of silk products is the consistency of the accounting boundary. The selected boundary has a direct bearing on the input and output within the studied system, further influencing the final results. For instance, Giacomin et al. [16] unearthed a positive correlation between silk garments and carbon footprint mitigation when including the cultivation of mulberry trees in the computation. According to the calculation conducted by Giacomin et al. [16], the carbon footprint per tonne of silk fibre was 25,425 kg CO_2e from fibre production to the end of the life cycle. Besides, Barcelos et al. [5] conducted a life cycle assessment for the core processes of mulberry and silk cocoon production and upstream processes of raw material production, turning out that the GWP result of mulberry production was 0.21 kg CO_2e per kg of silk cocoon. The average content of Brazilian silk in cocoons is approximately 17%, which means 1 tonne of silk fibre requires 5.88 tonnes of cocoons, with the GWP value of 1 tonne of silk fibre during the mulberry production of 12,348 kg CO_2e. Thus, based on their research and the above calculations, the carbon footprint result of 1 tonne of silk in the whole life cycle is about 37,773 kg CO_2e, without taking the carbon sequestration effect of mulberry trees into consideration. However, the ability of mulberry trees to sequester carbon is significant, and by planting a field of mulberry trees, the correspondingly mitigated CO_2e is approximately 735 times the weight of the produced silk fibre [16]. Taking a tonne of silk fibre for instance, the mitigated CO_2 by mulberry trees is about 735,585 kg CO_2e, which far surpasses the carbon footprint of the whole life cycle (37,773 kg CO_2e). Therefore, when the starting point of the accounting boundary of silk products is “cradle”, it is an essential account for the role of mulberry trees and explains the selected boundary separately. Any change in the accounting boundary brings about the volatility of the accounting results [1].

ACCOUNTING DATA

Within the accounting boundaries of carbon footprint, the sources of greenhouse gas (GHG) emission include direct GHG emissions and indirect GHG emissions. Specifically, GHG emissions from fuel burning (e.g., natural gas boiler combustion emissions), chemical reactions (e.g., carbon dioxide produced by carbonate reactions), and wastewater treatment (e.g., methane and nitrous oxide) [17] constitute direct greenhouse gas emission data. On the other hand, the off-site combustion energy consumed within the accounting boundaries (such as electricity), and materials (e.g., dyes, auxiliaries packing materials, etc.) fall under indirect GHG emission data.

Accounting data forms a basis for evaluating the carbon footprint of products. In this regard, ISO 14067: 2018 classifies accounting data into primary data, site-specific data and secondary data. Primary data refers to the data directly measured in the progression of the life cycle of a product or calculated from direct measurements. Site-specific data refers to the primary data obtained within the accounting boundary of the carbon footprint of a product, covering direct GHG emissions, activity data (AD) and emission factors. Outside of primary data, data not directly collected, measured or estimated, but rather sourced from published literature or an industry database, are collectively referred to as secondary data. Although personal respiration, as a basic physiological activity, is affected by labour intensity, its carbon dioxide emissions are usually not included in accounting data of the carbon footprint. The fixed assets include production equipment and factories

Table 1

CARBON FOOTPRINT ACCOUNTING DATA FOR SILK PRODUCTS

Process/stage	Sources of GHG emissions and sequestration		Data inventory
Acquisition of silk cocoons	Direct emissions	Fuel combustion	Wood, coal, natural gas and diesel
	Indirect emissions	Energy and heat production	Electricity, steam
		Material production	Mulberry leaves, fodder, paper, plastic film, lime, bleaching powder, packing material
Production of silk products	Direct emissions	Fuel combustion	Wood, coal, natural gas and diesel (transportation)
		Chemistry reaction	Sodium carbonate, baking soda
		Wastewater treatment	Wastewater quantity, influent COD concentration, effluent COD concentration
	Indirect emissions	Energy and heat production	Electricity, steam
		Material production	Cord material, paper, packing material, tags, fresh water, textile chemicals (dyes, aids, et al.), chemicals for wastewater treatment
	Direct sequestration	Wastewater treatment	Methane recovery
Sale and use of silk products	Direct emissions	Fuel combustion	Diesel (transportation)
	Indirect emissions	Energy production	Electricity
		Material production	Paper, packing material, fresh water, detergent
Disposal	Direct emissions	Fuel combustion	Diesel (transportation)
		Combustion, landfill	Waste silk products
	Indirect emissions	Energy production	Electricity
Recycle and reuse	Direct emissions	Energy combustion	Diesel (transportation)
	Indirect emissions	Energy production	Electricity
		Material production	Packing material, fresh water, chemicals

generating GHG emissions directly or indirectly. However, as they constitute long-term assets not limited to the production of a specific silk product, they are also not included in the carbon footprint accounting data of silk products. The main list of accounting data for the carbon footprint of silk products is displayed in table 1.

Depending on the varying measurement levels of enterprises, some of the data relating to GHG emission sources can be accurate concerning a specific silk product or a specific workshop section, while other data constitutes overall data falling within a certain period, such as the monthly lighting expenditures of a workshop. If the workshop produces multiple silk products at the same time in a particular month, the monthly lighting expenditures need to be allocated to the silk products and co-generation products according to product characteristics, such as production volume or value [18]. If there are several segments involved in data allocation within the accounting boundary, the chosen allocation methods should be consistent. For example, if the lighting power consumption of greige fabric in the pre-processing workshop is allocated according to value, the lighting power consumption of the printed fabrics should also be allocated according to value in the subsequent printing workshop. When by-products are generated in a chain segment, the accounting data in this chain segment also needs to be allocated. For instance, in the reeling stage, where silk, basin residue and silkworms are generated concurrently, the data in the reeling stage should be allocated among the three products. If the usefulness of by-products is low (such as solid waste) or the output of by-products is small (such as less than 1% of production), there is no need to allocate accounting data to this segment.

In addition to collecting input and output data for the accounting of the carbon footprint of silk products, the moisture content of products in each stage needs to be addressed. For instance, the moisture content of silk in the reeling stage is different from that of the re-reeling stage, so the output data in both stages should be separately rectified based on moisture content data.

GHG SEQUESTRATION

The definition of the carbon footprint of a product by ISO 14067:2018 includes the GHG emission and sequestration of a product during the life cycle. The related methods of GHG sequestration include plant absorption of carbon dioxide and conversion into biochar during photosynthesis, artificial carbon capture, storage and utilization, etc. Naturally, silk is not directly obtained from plants. However, the necessary mulberry leaves as well as oak leaves fed in a traditional sericulture mode along with the feed raised in modern industrial sericulture mode (including mulberry leaves, soybean meal, etc.) are plant-derived products. Moreover, the carbon they contain is traceable to carbon dioxide in the air. In addition to mulberry leaves, oak leaves or artificial feed are eaten by silkworms, and the carbon contained in leaves or feed is then converted into carbon dioxide and released into the atmosphere. The remaining carbon absorbed by the silkworms is eventually transferred to the silkworm excrement, silkworm chrysalis as well as the silk. Consequently, the carbon sequestration of mulberry leaves, oak leaves or artificial feed is not equivalent to the carbon sequestration of silk.

The quantification unit of the carbon footprint of a product is also carbon dioxide equivalent, which in turn refers to the total radiative forcing of methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride (SF_6), etc. in a given period (such as 50 years, 100 years) to an equivalent amount of carbon dioxide (CO_2) [19]. The impact of silk in terms of carbon fixation is impacted by the duration of the use of silk products. The greater the duration, the more significant the carbon fixation effect, and vice versa. Generally, the use of silk products does not extend more than fifty years. Consequently, while the carbon dioxide sequestration of silk biochar may not be included in the calculation of the carbon footprint of silk products, it can be explained in the form of a data list in the carbon footprint accounting report. When the carbon footprint accounting boundary is set as “cradle to grave”, burning waste silk products releases carbon into the atmosphere but generates heat concurrently. If this heat is utilized, the use of corresponding fossil fuels can be conserved and the measurement of GHG emissions can be reduced, which is equivalent to greenhouse gases sequestered.

If the silk product manufacturers sequester greenhouse gases from the atmosphere by purchasing carbon sinks or using artificial carbon capture, the greenhouse gases sequestered should be calculated into the carbon footprint results during accounting. To provide an example, if a manufacturer purchases a certain amount of carbon sinks and declares the share allocated to the silk products whose carbon footprint is to be accounted for, this amount can be used to offset the GHG emissions within the accounting boundary.

CALCULATION OF RESULTS

The quantification of the carbon footprint of various textile products during the production process is associated with complex and changeable production technologies and different processing modes [20]. As a result, depending on the production scenarios, the calculation for the carbon footprint of silk products involves different emission sources and calculation methods. Chemical reaction emissions of direct greenhouse gas emissions within the accounting boundary can be calculated through a chemical equilibrium equation, and GHG emissions incurred through the burning of energy can be calculated based on factors such as carbon content of energy, carbon oxidation factor, low calorific value and so on. Indirect greenhouse gas emissions within the accounting boundary can be calculated according to the method of GHG emission = AD * EF (AD represents activity data, and EF represents emission factor). AD consists of input data of off-site combustion energy (such as purchased electricity) and materials (such as dyes, auxiliaries, packaging materials, etc.), but the calculation of EF is relatively complex. When deriving the carbon footprint, EF data released by relevant institutions, as found in the literature and commercial databases, can be utilized. When choosing EF data, time and geographical differences should be fully addressed. For instance, if a certain silk product is manufactured in Zhejiang Province, and the electricity used in production is supplied by the East China Power Grid, the EF data for the power should be corresponding data released by the East China Power Grid.

Until now EF data remains a key factor restricting the calculation of carbon footprint results of products, and it is mainly manifested in incomplete data, poor timeliness, and incomplete geographic coverage. The lack of integrity of data refers to the fact that, for some materials, the EF data remains unavailable. For example, a portion of EF data concerning dyes that are utilized in the dyeing process of silk fabrics is still missing. Meanwhile, poor timeliness signifies that some of the existing EF data are outdated. For example, some data were obtained five years ago, ten years ago or even earlier. Incomplete geographic coverage refers to the fact that EF data only includes information relating to several specific areas. For instance, EFs for output power from grids prove dissimilar from one country or region to another, while published or researched EF data on electricity do not cover all countries and regions. With the deepening and expansion of research in the field of carbon footprint, EF data is still being dynamically updated. While calculating the carbon footprint of silk products, the selected EF data should be described in detail, as the consistency of EF data constitutes a key prerequisite for the comparability of different silk products within the same accounting boundary.

The results of the calculation regarding the carbon footprint of silk products equal the sum of carbon footprints in each process within the accounting boundary, and it is reported as the carbon footprint of the functional unit product. Different functional units should be set according to different product categories. For example, in the reeling stage, the unit weight of white silk is normally set as the functional unit; in the weaving stage, the unit weight or the unit meter of greige fabric is normally set as the functional unit; in the manufacturing stage of the finished product, a silk garment, a silk scarf or a silk quilt is generally set as the functional unit. When a functional unit is a non-weight unit, such as a meter, piece or bar, the weight information should be noted to facilitate the accurate conversion if the carbon footprints of different processes are compiled.

CONCLUSIONS

As the life cycle chain of silk products is long and comprises numerous contributory and productive elements, it is necessary to completely and systematically analyse the key issues of carbon footprint accounting of silk products to ensure the validity and comparability of carbon footprint accounting results. In this study, we discussed key issues such as accounting boundary, accounting data, GHG sequestration and calculation of results in the process of assessment of the carbon footprint of silk products.

Accordingly, when accounting for the carbon footprint of silk products, the accounting boundary should be set according to accounting needs. In this regard, it is usually feasible to choose a "gate" as the endpoint of the accounting boundary. The integrity and accuracy of accounting data constitute a key basis for carbon footprint accounting. In addition, the key GHG emission sources within the accounting boundary should be identified as well. Meanwhile, to ensure the quality of the accounting data collected, the data distribution method needs to be selected appropriately. Moreover, the GHG sequestration effect of silk is affected by the duration of usage of silk products. When reporting the carbon footprint of silk products, the GHG sequestration amount corresponding to biochar can be separately stated. Besides, the carbon neutralization actions of silk enterprises can be incorporated into the carbon footprint quantification results of silk products. On top of that, EF data affects the accuracy of calculation results of the carbon footprint of silk products. Finally, a consistent accounting boundary and consistent EF data constitute the two key prerequisites for the comparability of the calculated results expressing the carbon footprint of different silk products.

The accounting of the carbon footprint of silk products provides an important reference for the low-carbon design of silk products, carbon emission reduction in the manufacturing process, and green and low-carbon consumption by consumers. It is also of great significance for the green and low-carbon development of the silk industry and other textile products.

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Authors:

LIU CAN[1], LI QIZHENG[2,3], LIU SHUYI[1], LI XIN[1], ZHANG YING[1], WANG LAILI[1,4,5]

[1]Zhejiang Sci-Tech University, School of Fashion Design & Engineering,
310018, Hangzhou, Zhejiang, China
e-mail: liucan0425@163.com (L.C.), liushuyiiii@163.com (L.S.), listen89@163.com (L.X.),
zhangying1221@hotmail.com (Z.Y.)

[2]Zhejiang Sci-Tech University, International Institute of Silk, 310018, Hangzhou, Zhejiang, China

[3]International Silk Union, 310018, Hangzhou, Zhejiang, China

[4]Research Center of Digital Intelligence Style and Creative Design, Zhejiang Sci-Tech University,
310018, Hangzhou, Zhejiang, China
e-mail: wangll@zstu.edu.cn (W.L.)

[5]Green and Low-Carbon Technology and Industrialization of Modern Logistics,
Zhejiang Engineering Research Center, 325103, Yongjia, Zhejiang, China

Corresponding author:

LI QIZHENG
e-mail: liqizheng@zstu.edu.cn