Prospective LCA of innovative pharmaceuticals using transgenic silkworms

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1. Introduction

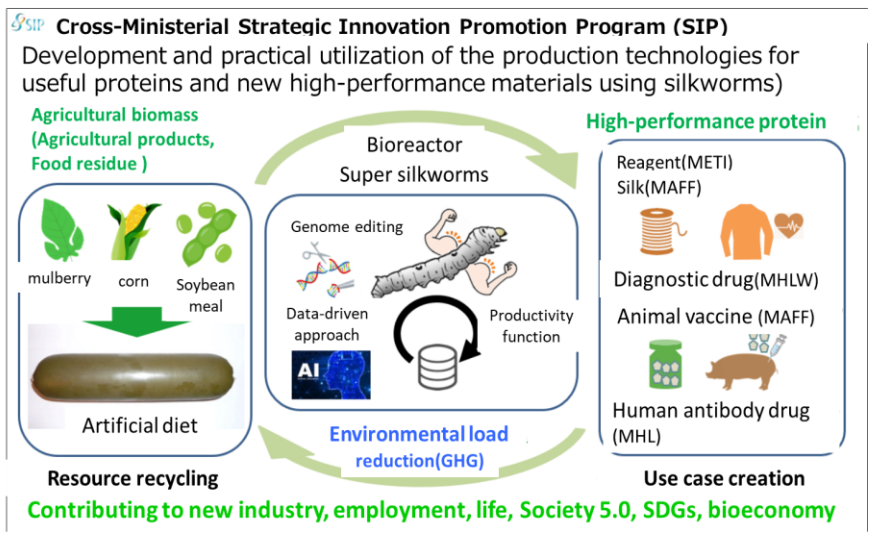

Fig.1: Framework of this project regarding silkworms

Social background

In an age with a declining birthrate and aging population, the role of pharmaceuticals in maintaining and managing life and curing diseases has become more and more important.
On the other hand, in the manufacturing of pharmaceutical products, certain raw materials and special manufacturing equipment make the environmental load larger.

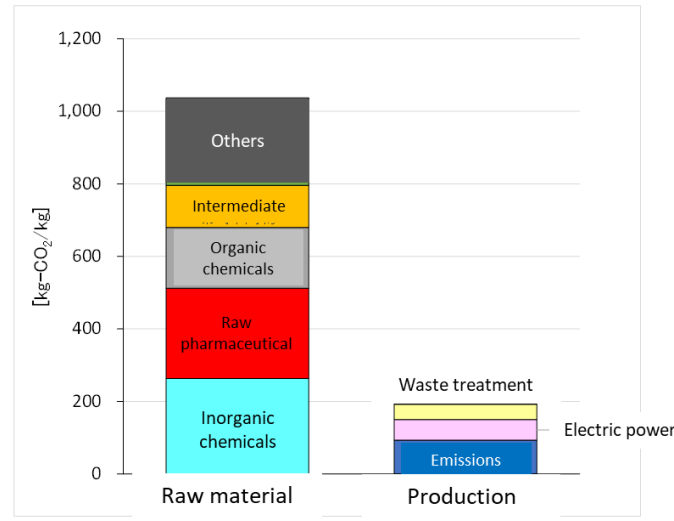

Fig.2: Manufacture of pharmaceutical preparation

2. Method

Goal

In this study, although the environmental load per functional unit is large on the lab scale, a prospective life cycle assessment (LCA), which is expected to reduce the environmental load on a production scale, was applied to the pharmaceuticals manufacturing.

Prospective LCA

Although the environmental load per functional unit will be large on the lab scale, Prospective LCA is an LCA method that anticipates the reduction of the environmental load on a production scale.

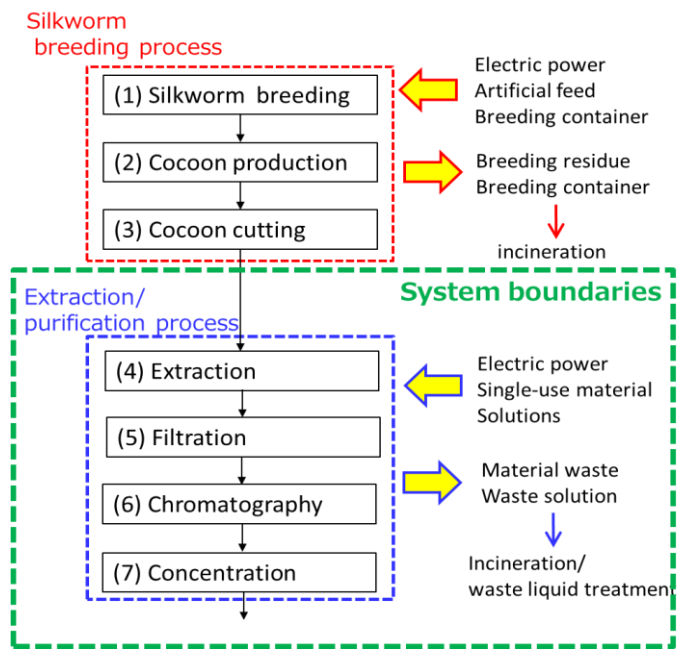

Fig.3: System boundaries of Extraction/purification process

Table 1: Comparison of conventional LCA and prospective LCA

	Conventional LCA	Prospective LCA
Definition	System modeled at a current or near-by time	System modeled at a future time
Technology alternative	Currently existing technologies are studied.	Emerging technologies with relevance for the future are studied
Foreground system data including production scale	Current foreground system and production scale are modeled. Common data sources include: life cycle inventory databases previously conducted LCA studies	A future scenario of the foreground system and production scale is modeled. Valuable data sources include: scientific articles patents expert interviews unpublished lab results process simulations
Background system data	Current background system is modeled.	A future scenario of the background system is modeled. Important to avoid temporal mismatch between the foreground and background systems. Potential for not modeling background system at all.

(Rickard Arvidsson , *Anne-Marie Tillman, Bj¨orn A. Sand´en, Matty Janssen, Anders Nordel¨of, Duncan Kushnir, and Sverker Molander*: J.Industrial Ecology, 22, (2017), pp.1286-1294)

3.Results

The lab scale and the pilot scale

	Operation	Number of equipment	Size of equipment
①Lab scale	Sequential	Singular	Existing equipment
②Pilot scale1	Simultaneous	Singular	Existing equipment
③Pilot scale2	Simultaneous	Multiple	Existing equipment
④Pilot scale3	Simultaneous	Multiple	Large equipment

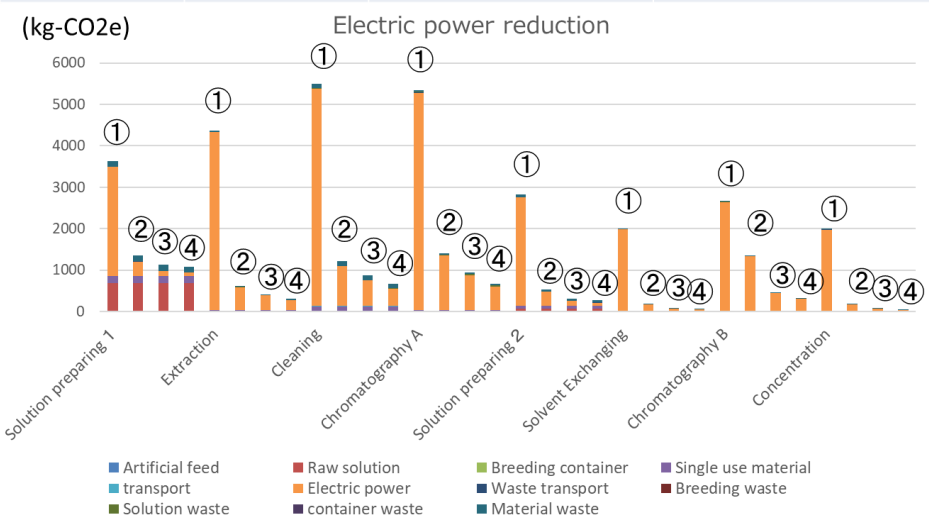

Fig.4: Calculation results for the pilot scale

The production scale

	①Pilot scale 2	②Production scale A	③Production scale B
Floor area of Chromatography	1	1/2	1/2
Separation time of Chromatography	1	1/2	1/10
Whole process time (In line)	1	1/2	1/2
Electricity for clean room	1	1/5	1/10

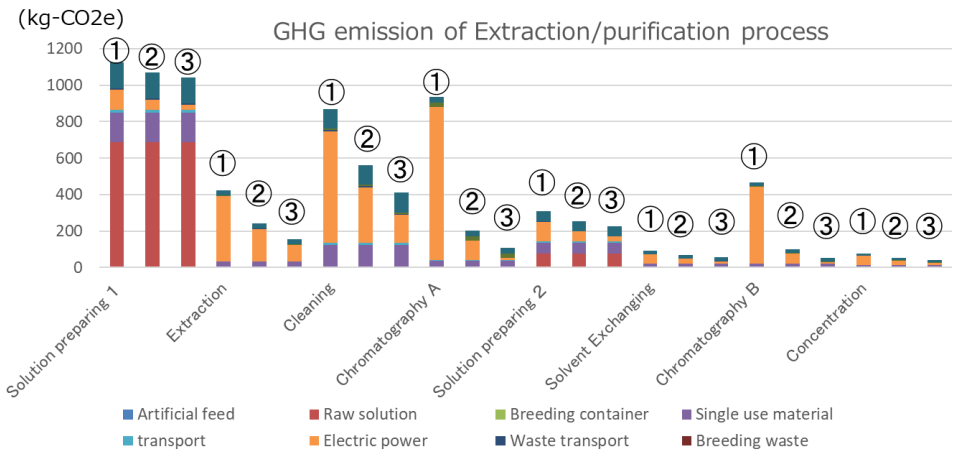

Fig.5: Calculation results for the production scale

Trial calculation for actual raw pharmaceuticals

A calculation was performed using clinical test pharmaceuticals for a blood coagulation test. Currently, these pharmaceuticals are derived from animals (the brain of rabbits), so CO2 is emitted during breeding and the production of raw materials. When silkworms are used, the CO2 emissions are about 1/10 of the current.

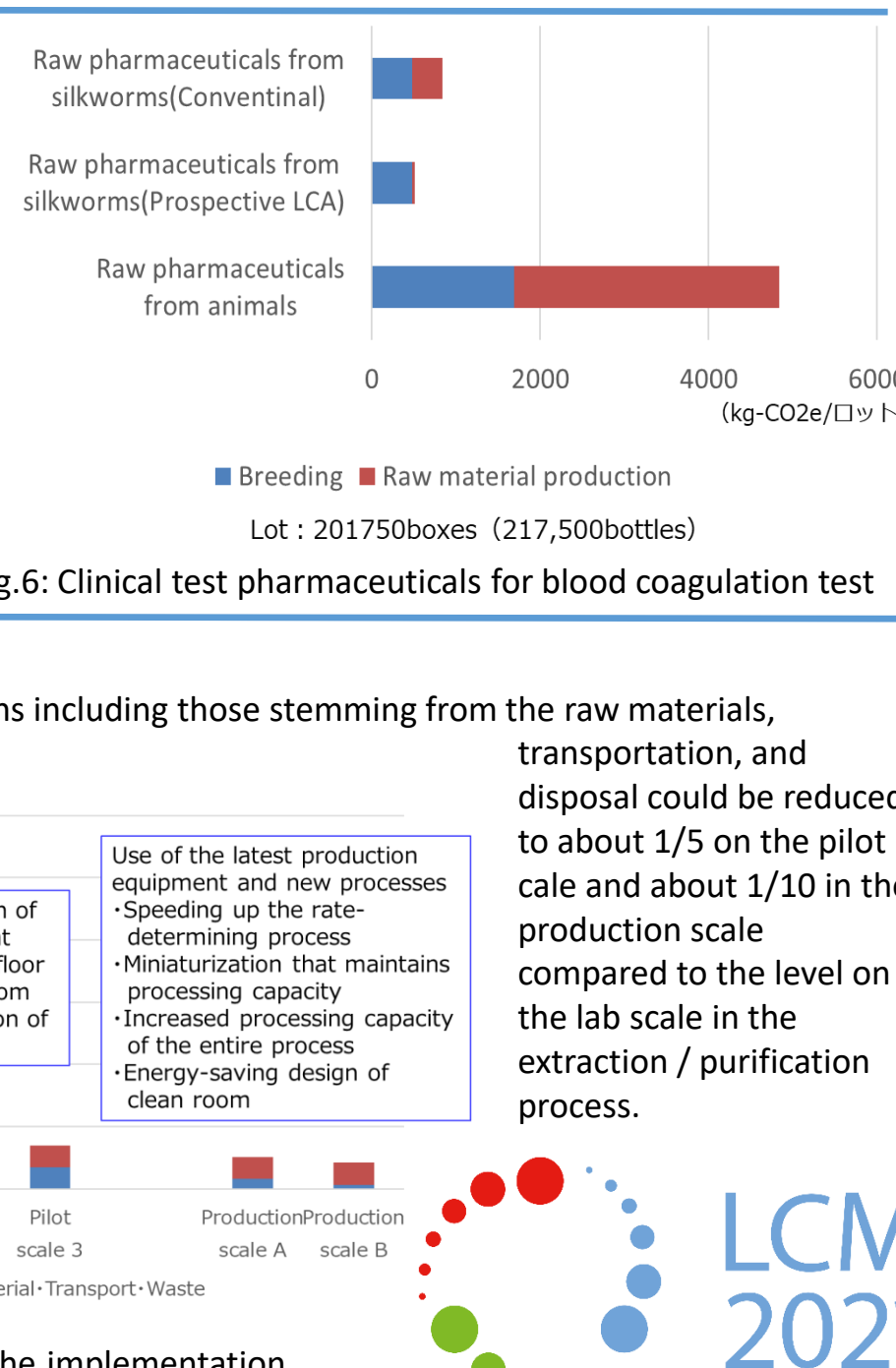

Fig.6: Clinical test pharmaceuticals for blood coagulation test

4. Summary

It was confirmed that GHG emissions including those stemming from the raw materials, transportation, and disposal could be reduced to about 1/5 on the pilot cale and about 1/10 in the production scale compared to the level on the lab scale in the extraction / purification process.

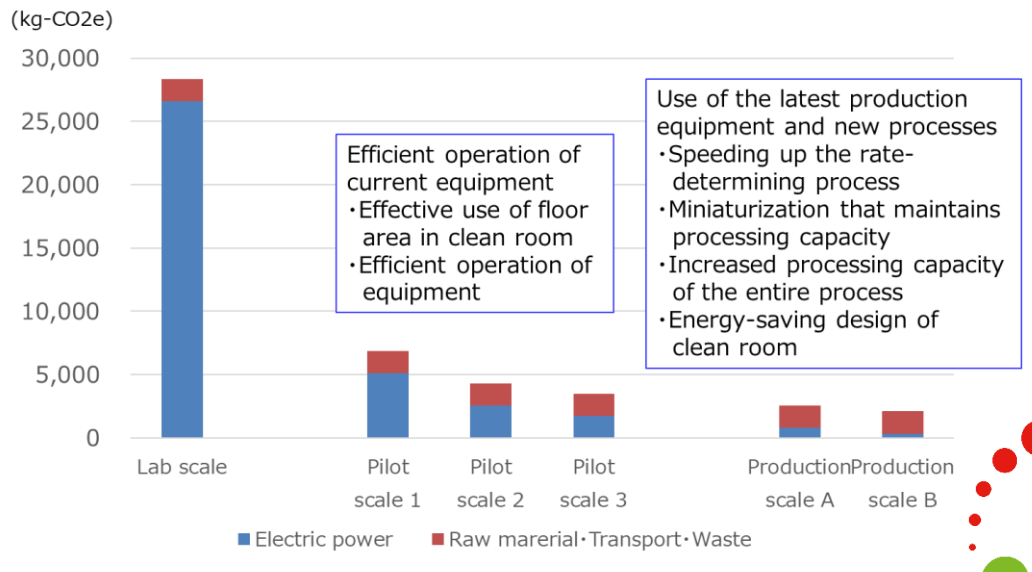

Fig.7: Summary of the implementation of the prospective LCA

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