

Preliminary techno-economic analysis for food waste valorization via black soldier fly (*Hermetia illuscens*)

Haley Stockham¹, Ajay Shah^{1*}

INTRODUCTION

Food waste

- 40% of the U.S. food is wasted¹.
- Currently, food waste is primarily anaerobically digested, composted, and landfilled.
- All these demand high logistics expenditure.
- An alternative promising method for food waste valorization is using black soldier fly (BSF) (*Hermetia illuscens*).
- BSF has considerable potential to manage the world's organic waste, especially as they are hardy and non-nuisance.
- The larvae can thrive on diverse organic wastes and adult BSF do not eat, sting, or invade homes.
- Existing large scale BSF waste management facility can process 1 t/day of biomass waste.²

Black Soldier Fly Larvae (BSFL)

- The resulting pupae have desirable nutritious value for fish, pet, or chicken feed: 11.8-34.3% fat and 31.7-47.6% protein contents³ (Fig. 1).



Fig. 1 Larvae dried for pet food⁴

- The high fat content indicates potential for other valorization pathways, including biodiesel.⁵
- The key focus on this system is larvae-pupae stages; however some pupae will need to mature to adulthood to maintain a breeding population (Fig. 2).

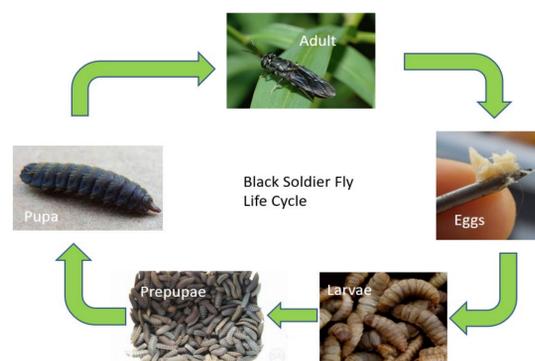


Figure 2. BSF lifecycle: durations of each stage impact the scale of the food waste treatment facility

Objective

Evaluate the techno-economic feasibility of food waste valorization using BSF and resulting BSFL as chicken feed.

METHODS

System Boundary: food waste acquisition through conversion to oven-dried BSFL for chicken feed (Fig. 3).

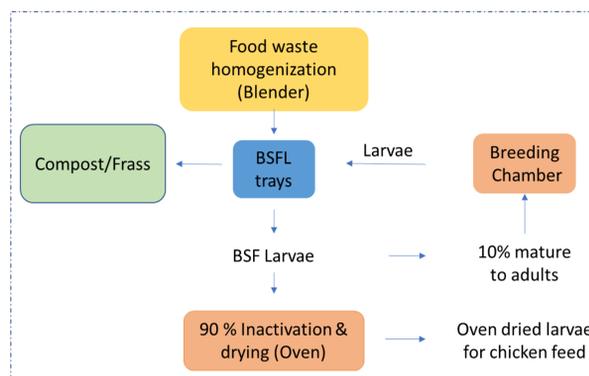


Fig. 3. System overview for the process

Data sources: literature

Key Assumptions:

- Target Waste Management: 7.3 t/day
- Successful implementation of food waste management guidelines to eliminate need for screening to separate organic and inorganic wastes.
- Food waste requires no moisture addition or reduction.
- 5-day old larvae (5-DOL) are capable of treating 15 kg food waste over a period of 12 days.⁶
- The BSF feed production cost is reported on a \$/t basis.

Operating Input Parameters: Food waste moisture content, waste-to-biomass conversion ratio, survival rate, successful pupation rate, number of eggs/breeding female

Financial Inputs: Loan payback period, interest rate, start up capital, machinery and equipment costs, utility rates, labor estimates, current retail price of oven-dried BSFL, tipping fee

Operating Outputs: daily egg production, number of breeding adults, kg BSFL/day, remaining quantity of wet waste residue, required equipment

Financial Outputs: production cost of BSF feed (\$/t), annual net revenue (\$/y)

RESULTS

Capital Investment

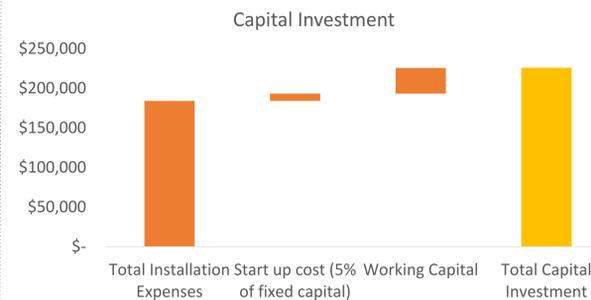


Fig. 4. Capital investment required for startup of BSF food waste treatment facility

- The low cost of equipment and machinery for this facility is reflected in the total installation expenses, which is around \$185K.

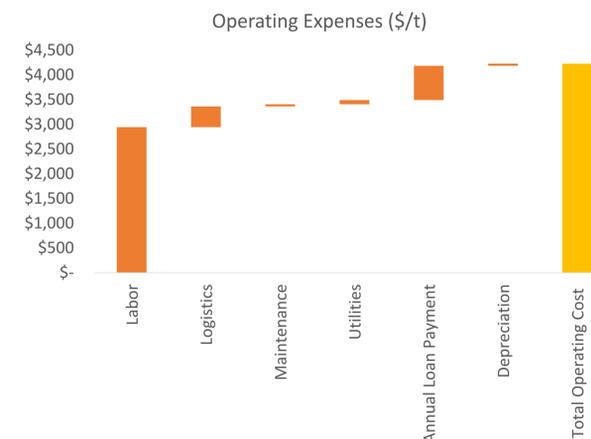


Fig. 4. Operating cost (\$/t BSF) of BSF food waste treatment facility

- Labor costs contribute most to operating costs.
- No consumables required other than personal protective equipment for personnel.
- This operational process is low tech: it requires low utility use and maintenance expenditures.

Sensitivity Analysis

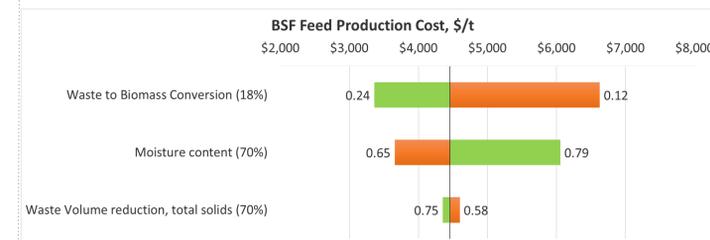


Fig. 6. Sensitivity analysis of BSF feed production cost

- The sensitivity analysis indicates that the most critical component of the BSF production cost is the waste-to-biomass conversion ratio, followed by moisture content of the food waste and waste volume reduction on a total solids basis.

CONCLUSIONS

- BSF food waste management system shows potentials to be economically feasible and would provide a revenue stream.
- BSF production cost can be reduced by increasing waste-to-biomass conversion rate and minimizing moisture content of food waste.

BROADER IMPACTS

- Food waste valorization contributes to circular economy
- The model estimates that the net annual revenue of this facility would be roughly \$0.5 million.
- Waste valorization model that can be extended to communities with limited infrastructure and resources

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