Black soldier fly biowaste treatment and its recycle waste to produce chitosan

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Abstract. Recycling organic of house waste remains fairly limited especially in urban area with low-and middle-income. A novel approach is developing method to manage the organic waste conversion using larvae Black Soldier Fly (BSF). The advantage of this approach links to the green technology waste management which is no pollutant effect to the environment as well as increase the added value economically. The research project successfully presented organic house waste conversion into high protein of animal feeding source. From the 5 dol of larva BSF’s (approximately 17 gr), it was reduced organic waste ± 0.7 kg/day. Within 10 days, the larva BSFs of 17 dol was consumed organic waste ± 10 kg, with increase their weight to become approximately 10 kg. The larva BSF of 17 dol is potential as animal feeding source that contain a high of protein. Furthermore, the waste from BSF’s cycle life is potentially to convert into chitosan, due to contain of chitin. Chitosan was produced from the waste of larvae skin, pupa skin and insect imago death. In general, this organic waste management is offering to green organic waste management in the future.

1. Introduction
Indonesia as a developing country face tremendous challenges to provide green waste management system. Particularly Surabaya with rapid urbanization and population growth, lacking financial as well as limited skilled human resources cause complexes problem in waste management. In low- and middle-income countries usually the waste management system still rely on low collection rate and inadequate waste disposal [1]. The worse and uncontrolled organic waste management cause serious problem in methane release into the environment that contribute to the global methane emission [2]. Alternative of waste management which provide a lot of advantages will attract a lot of people particularly creation of product with economic value [3,4]. The detail of pathway recycle for biowaste is explained by Lohri et al [5]. From the various methods of waste management, this study has considered to choose using larvae BSF as method for waste management due to green and contribute to the economic value. The main objective of the present study was therefore to fill this research gap by evaluating the capability of larvae to process organic waste, and the ability to produce chitosan from biowaste BSF with organic waste as the feed intake.

2. Research Methodology
2.1 Location of the Study
The research activity was located at RW 11 Kertajaya, Surabaya and Nyampah Corp Surabaya.
2.2 Black Soldier Fly (BSF) Colony
Population of black soldier fly (BSF) was attracted from the natural ecosystem and kept in four different cages of size 60 × 60 × 50 cm. It was covered by transparent mosquito nylon net and exposed to direct sunlight. Organic waste was used to attract the BSF female for oviposition. For 4 days, the eggs were remained in the pre-feed period. Further, the young larva (4-6 days old) was collected in a week. The larvae were kept at ambient temperature (25-26°C) in the box container with humidity approximately at 60-85%.

2.3 Organic Waste Processing
The population of larvae ± 5 dol ages were kept in four different rack of size 1100 × 600 × 400 cm, which each rack contains 12 boxes (each box approximately 26L) and completed with drain tap at the bottom. The lid of boxes was made from aluminum net, to avoid predator. Organic waste from RW 11 Kertajaya, Surabaya everyday was collected and separated, then put into the plastic boxes. Further, the larvae were consumed organic waste daily until achieve ± 17 dol ages in two weeks. After approximately 2 weeks, the total larvae were measured the weight. The measurement of organic waste household was measured.

2.4 BSF’s Cycle Life Waste Processing to Produce Chitosan
The farm of BSF was produced biowaste involve skin prepupae, skin pupae, and death insect imago adult. Due to contain of chitin from the BSF biowaste, it is potentially to produce chitosan as derivative of chitin. Biowaste from BSF was proceeded become chitosan powder using microwave assisted. Three types of biowaste was washed and boiled, then dried. Furthermore, each of biowaste was crushed with diskmill and sieved at 560 and 112 µm. Chitosan production was conducted at 720 watts for 90 minutes. The purification was continued using 2%wt of acetic acid.

3. Results and Discussions
The larvae ±5 dol was started to use as organic waste treatment, which depicted in Figure 1(a), while larvae ± 17 dol revealed in Figure 1(b). The size difference was performed in Figure 1(c). For 2 weeks waste treatment process, its significant increase the size and weight of larvae. Organic waste household can be used as feed source to growth for larvae. Diener et al reported that the feed source significant influence the growth of larvae [6]. The rack contain 12 boxes was used as method for organic waste treatment. Four rack was employed to present the fourrepetition measurement.

![Figure 1](image)

**Figure 1.** (a) larvae ±5 dol, (b) larvae ±17 dol, and (c) difference size between ±5 dol and ±17 dol

The beginning proses was started to spread larva ±5 dol into 12 boxes. The total of larva ±5 dol was performed approximately 17 gram/rack, which revealed in Figure 2. After two weeks, larva ± 17 dol was increased the weight approximately 10 kg/rack (Figure 3). This means organic waste household is a good source of food for larva BSF.
The larva BSF was transformed into a high protein feed source for animals. The prepupae in the last-minute stage exhibit large protein (34-48%) and fat (31-33%) [7,8]. The demand for animal feed production increases and depends on protein and fat from forage fishery. Due to the diminishing global market from forage fishery, animal feed industries find other alternative protein sources. Larvae BSF is potentially as a new source of protein for animal feed [8,9]. The other advantage from this method, the larvae were produced compost during waste treatment. The quality of compost resulted was influenced by feeding rates [10].

The compost resulted was produced a good quality for fertilizer in agriculture due to high carbon to nitrogen ratio [11,12], high carbon to phosphorous ratio [13], and reduce heavy metal [14,15,16]. The loss of carbon during composting could be caused by respiration activity of larvae through the skin [17]. In addition, the eating habit and movement activity of larvae contributed to reduce the carbon [18]. The most important, BSF method was contributed to low of emission compare than composting process [19], which potentially to against a global warming issue. For 10 days, the total organic waste consumed by larvae was measured approximately 10 kg/rack, because everyday the waste treatment was set up to consume 1 kg/rack of organic waste (Figure 4). This result is in line with Dortmans et al [20]. SBF was produced biowaste involve prepupae skin, pupae skin and insect, which revealed in Figure 5.
Figure 6. Amount biowaste of BSF before and after diskmill process

The large biowaste was contributed by death insect (Figure 6). The most advantage from BSF biowaste is contain chitin both in prepupa and pupa skin as well as in insect. Industries interest on chitin due to ability to process into chitosan, which as useful chelating agent and anti-bacterial. Widespread application of chitosan cause increases the demand on it. Extracting of chitin become chitosan from BSF has still to be assessed. Using the microwave assisted, the study was transformed chitin become chitosan in 90 minutes at 720 watts, which illustrated in Figure 7.

Figure 7. Chitosan powder resulted from biowaste BSF, sieve 560µm for (a) prepupa, (b) pupa, (c) insect imago, sieve 112 µm for (d) prepupa, (e) pupa, (f) insect imago

The chitosan can be processes double amount from prepupa and pupa skin, compare than from insect. This result was indicated that prepupa and pupa skin contain more chitin compare than cuticle of insect. The source of chitin that be able to derivate into chitosan become variety, it is not only from shrimp skin and crustae shell but also from larva BSF skin and insect, as well as from mushroom. The mineral content of BSF and larvae depend on the given diet (food consumption) [21,22]. It also similar for the chitin contain in the BSF and larvae, the chitin contain also influenced by food intake, which in line with mineral contain of nitrogen. Measurement of chitin from biowaste larvae and insect were depicted in Table 1.

Table 1. Amount of chitin measurement after extract process in larva skin and insect imago BSF

|                | Prepupae | Pupae | Insect Imago |
|----------------|----------|-------|--------------|
|                | 4.82%    | 4.68% | 0.72%        |
4. Conclusions
The study was successfully performed organic waste treatment from household with capacity of 10 kg/day of waste from ± 17 gram of larva ± 5 dol ages. At harvesting (after 2 weeks treatment) the total weight of larva become 10 kg (± 17 dol ages). In addition, the biowaste BSF was successfully processed become chitosan powder. In general, the waste management using BSF is promising a green technology and give additional added value product with spread of application.

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