Analysis of kitchen organic waste for processing using Black Soldier Flies in Kecamatan Cibiru, Bandung, West Java

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Abstract. Black Soldier Flies (BSF) is a type of fly that is larger than ordinary flies and is famous for its ability to consume and reduce organic waste, especially kitchen organic waste (KOW). KOW processing using BSF will be carried out in Kecamatan Cibiru, Bandung City, so the characteristics of KOW produced by the community need to be analyzed. The number of samples is calculated based on SNI M 36-1991 on Method of Taking and Measuring Example of Formation and Composition of Municipal Waste, obtained 63 households, which are then divided into 3 income groups. Results show the average KOW generation in populations with high, medium and low incomes are 0.223, 0.153, and 0.103 kg/person/day, respectively. Based on the speed of consuming KOW by BSF where the composition of KOW is divided into 3 categories, the results are obtained that 47% KOW is consumed quickly, 29% KOW is consumed slowly, and 24% KOW is not consumed. It was also found that the high income population turned out to contribute the highest fast eaten KOW compared to the middle and low income population. This turned out to be influenced by cooking patterns and patterns of handling leftovers.

1. Introduction

*Hermetia illucens* known as Black Soldier Fly (BSF) is an insect belonging to the order Diptera, Family Stratiomyidae, subfamily Hermetinae. BSF is a holometabolous insect: the transition from the larval stage to the adult stage occurs following the process through the nymphal stage. Complete transformations, larvae and adult insects have contrasting morphology and life habits [1]. Currently BSF is widely used as animal feed because it has high levels of nutrients [2,3] and high protein [4].

Bioconversion is a process by involving microorganisms such as yeast, fungi, and bacteria or alternatives to terrestrial invertebrates such as insect larvae to convert organic waste into higher value products, such as biodiesel [5]. Bioconversion is a continuous process that utilizes insect larvae to transform organic waste. Furthermore, the insect larvae convert nutrients from waste and are stored as biomass [6]. BSF larvae have been propagated as organic waste converter agents because these larvae eat ravenously various decomposed organic matter and produce prepupa containing 40% crude protein and 30% fat as food for fish and other livestock. The use of BSF as animal feed can cover the financing of waste management in low and middle countries [6]. The potential for heavy metals in the waste must be wary because it can accumulate in prepupa [7].
The reduction of various organic wastes by BSF larvae has been studied by the researchers namely reduction of human waste material by 51.3% and reduction of poultry feed 84.9% [8]. Furthermore, reduction of cow dung 33-58% and chicken manure 50% [9,10] and reduction of municipal organic waste 66-79% [10]. Compared to types of animal waste, fruits and vegetables, it turns out that kitchen waste has the highest reduction rate per day [11,12], as well as restaurant waste [13]. The rate of waste consumption by BSF larvae varies according to the type of waste, moisture content, numbers of larvae, larval size and temperature [14].

Kecamatan Cibiru, located in Kota Bandung, West Java Province, was chosen as a research location because it planned to develop kitchen organic waste treatment using BSF. Analysis of the characteristics of kitchen organic waste is important to know and can be used as a basis for planning the kitchen organic waste treatment system.

2. Research methodology

2.1. Data collection
Data collection is used to find out information on characteristics of households in the service area as well as the characteristics of the handling of waste carried out. And also primary data collection by sampling organic kitchen waste in the service area.

2.2. Sampling
The method of collecting and measuring solid waste generation in Indonesia is carried out based on SNI M 36-1991 on the Method of Taking and Measuring Examples of Urban Waste Incidence and Composition. The type of analysis carried out is the measurement of weight, composition, specific gravity and water content of organic kitchen waste. The total population in Kecamatan Cibiru is 62,060 people, so there are 250 person samples. The average population per family is 4, so the number of household samples is 63 households. Based on the data distribution of income of Bandung city residents in 2017, the sample size of households is divided into 3 categories: high income 13 households (20%), middle income 25 households (40%) and low income 25 households (40%). Table 1 shows the distribution of research sample households.

| No | Kelurahan | Households classification |
|----|-----------|--------------------------|
|    |           | High Income | Middle Income | Low Income |
| 1  | Cisurupan | 2 HH         | 6 HH          | 5 HH       |
| 2  | Palasari  | 5 HH         | 6 HH          | 4 HH       |
| 3  | Cipadung  | 4 HH         | 8 HH          | 7 HH       |
| 4  | Pasir Biru| 2 HH         | 5 HH          | 9 HH       |

3. Result and discussions

3.1. Households sample characteristics
The characteristics of high-income households are husband and wife working with an income of more than 5 million rupiah and a house area of more than 120 m². As many as 93% always cook at home every day and the rest use catering services. Frequency of eating 3 times a day (77%) and the rest 2 times a day, and 99% do not like reheated food. With a relatively high purchasing power, this causes the composition of kitchen organic waste produced more varied and has the potential to be used as feed from BSF larvae.

Characteristics of middle income households are husband or wife working with income of 3-5 million rupiah and house area of 90-120 m². All household samples eat at home 2-3 times a day. 88% of respondents cook once a day and the rest cook 2 times a day. The remaining food that is still suitable for consumption is usually reheated once or twice, but if it is not feasible, 73% of respondents immediately dispose of it and 27% of respondents give it to livestock. The characteristics of
low-income households are husband or wife working as laborers or honorary staff with income of 1-3 million rupiah and the area of the house is less than 90 m². All households cook with frequency only once every 2-3 days. This happens because they are accustomed to reheating the remaining food until the food runs out. Not all kitchen organic waste produced is disposed of, because 32% of respondents use it for animal feed, 28% use it for agricultural fertilizer, and the remaining 40% is directly disposed of.

3.2. Generation of kitchen organic waste
The results of 8 days of kitchen organic waste sampling from sample households are shown in Table 2.

| Day | Number of Person | Generation (kg/person/day) |
|-----|------------------|-----------------------------|
|     | High  | Middle | Low  | High  | Middle | Low  |
| 1   | 52    | 100    | 100  | 0.221 | 0.135  | 0.085 |
| 2   | 32    | 92     | 52   | 0.229 | 0.149  | 0.106 |
| 3   | 52    | 76     | 40   | 0.258 | 0.155  | 0.088 |
| 4   | 40    | 76     | 60   | 0.291 | 0.168  | 0.110 |
| 5   | 52    | 68     | 64   | 0.174 | 0.119  | 0.121 |
| 6   | 52    | 92     | 56   | 0.200 | 0.134  | 0.100 |
| 7   | 52    | 80     | 96   | 0.205 | 0.193  | 0.092 |
| 8   | 40    | 100    | 48   | 0.208 | 0.169  | 0.121 |
| Total | 1.786 | 1.222  | 0.822 |
| Average | 0.223 | 0.153  | 0.103 |

From Table 2 it is known that the highest kitchen organic waste generation is in the High Income house. The lowest amount of kitchen organic waste comes from the Low Income house, while the Middle Income house is in between. Similar to the results of research in the City of Dehradun India [15]. One of the factors that influence the amount of waste generation is consumption patterns or eating habits. This is different from the results of research in Istanbul, where high income contributes to organic waste lower than middle and low income [16] because most of them eat outside the home. The average sampling results of kitchen organic waste generation for each person in Kecamatan Cibiru were 0.16 kg / person / day. The potential of organic kitchen waste can be obtained optimally if people want to sort it from home. To increase the success of sorting at the source, a sorting campaign with a touch of psychological factors is needed, such as a model developed in Beijing City [17].

3.3. Composition
The composition of kitchen organic waste is divided into three categories based on the ability of BSF larvae decompose organic kitchen garbage, which is consumed quickly (CQ), consumed slowly (CS) and not consumed (NC) by the larvae (Table 3). These three categories are the results of direct observations of BSF larvae in TPS Cipamokolan RW 2 Gede Bage Bandung and compared with existing studies, shown in Table 3. The type of waste has a great influence on the quality of BSF produced [10]. Apart from the type of waste, larvae density and feeding rate also affects the bioconversion process [18]. The results of the study of the composition of kitchen organic waste for each household classification are shown in Table 4. The recapitulation of types of kitchen organic waste is shown in Figure 1.
Table 3. Time of decomposition waste categories.

| No | Categories          | Time (minutes)                          | Example                                                                                                                                                                                                 |
|----|---------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Consumed Quickly    | - leftover rice: 1 hour 47 minutes      | Rice, cooked meat, fruits, refined vegetables (spinach, mustard leaves, kale leaves, mushrooms and the like) rotten tempeh, tofu and kitchen scraps that tend to be densely textured soft. |
|    | (CQ)                | - cooked fish: 4 hours 56 minutes       |                                                                                             |
|    |                     | - soft vegetables: 2 hours 43 minutes   |                                                                                             |
|    |                     | - banana type: 3 hours 13 minutes       |                                                                                             |
|    |                     | - mango type: 4 hours 2 minutes         |                                                                                             |
|    |                     | - Bread: 2 hours 57 minutes             |                                                                                             |
| 2  | Consumed Slowly     | - Raw fish/meat: 22 hours 26 minutes    | Raw hard vegetables (carrots, broccoli, cauliflower, onions and the like), raw meat, fried tempeh, kale vegetable stems, a kind of apple flesh, inner melon or watermelon skin, inner orange peel, papaya skin and the like. |
|    | (CS)                | - Apple type: 6 hours 40 seconds        |                                                                                             |
| 3  | Not Consumed        | -                                       | Hard, coarse and dry texture (Banana Bogol, Avocado Skin, Fruit seeds, dried apple peel, outer orange peel, outer banana peel, outer melon skin, pineapple peel, hard vegetable stems and the like) |
|    | (NC)                | -                                       |                                                                                             |

Source: Observations and Eewag [19].
Description: The number of larvae in test 1: 1 with various types of waste are tested (350 g and 350 g larvae types of waste)

Table 4. Recapitulation of kitchen organic waste composition based on household classification.

| Classification | Total  | CQ    | CS    | NC    |
|----------------|--------|-------|-------|-------|
| High Income    | kg/p/d | 0.227 | 0.108 | 0.07  | 0.049 |
|                | %      | 47.6  | 30.8  | 21.6  |
| Middle Income  | kg/p/d | 0.148 | 0.077 | 0.044 | 0.027 |
|                | %      | 51.8  | 29.9  | 18.4  |
| Low Income     | kg/p/d | 0.095 | 0.035 | 0.024 | 0.036 |
|                | %      | 37.2  | 25.3  | 37.5  |

Figure 1. Comparison of total types of kitchen organic waste.

In Table 2, show that the composition of organic waste at the source is influenced by income, the higher the income the greater the amount of organic waste generation per person. This shows that the generation of waste is influenced by several factors including their lifestyle and economic conditions. In contrast to the theory expressed by Damanhuri [20] that the simpler the lifestyle of the people, the more organic waste components (leftovers, etc.). This happens because they buy raw materials from the market, where people with higher income will buy ready-to-eat food. This theory is supported by
the results of research conducted by Cointreau [21] regarding the typical composition of residential organic waste for the Low Income category by 40-85%, for the Middle Income category by 20-65%, and for the High Income by 20-50%.

Figure 1 shows that in Kecamatan Cibiru, organic kitchen waste with a fast consumption category has a higher proportion than other categories. This means that 76% of kitchen organic waste can be processed using BSF, and only 24% of organic residues will be disposed of to landfill. However, different results were obtained by studies in Beijing which stated that household size and income showed a negative relationship with waste generation [22]. However, based on the results of composition sampling conducted in Kecamatan Cibiru, it shows an inversely proportional to the above theory. Higher purchasing power in the middle and upper income housing categories, supports a greater variety of waste components. Whereas in the Low Income category the variation of kitchen organic waste components was the least due to limited purchasing power. This is also consistent with the results of the interview described in Section 3.1 above.

3.4. Density and water content

Based on the results of solid waste research in Kecamatan Cibiru, it can be seen that the specific gravity for kitchen organic waste is 514.77 kg/m$^3$. From the results of the solid waste test it can be concluded that Kitchen Organic Waste produced in Kecamatan Cibiru is dominated by wet waste so that the density value obtained is very high.

The results showed the water content in the kitchen organic waste sample at the Solid Waste and B3 ITB Laboratory obtained a moisture content value of 72.88% Wet Weight. The optimum water content in BSF larvae food is between 60-90% [15]. When the water content of the garbage is too high it will cause larvae to come out of the breeding reactor, looking for a drier place. However, when the water content is low will result in less efficient food consumption [15]. If the water content is too high it also results in difficulty separating residues from insect biomass so it is considered necessary to regulate the water content of the waste before it is processed using BSF [3].

4. Conclusion

Based on the research, it was found that the organic kitchen waste generation in Kecamatan Cibiru was influenced by income, the higher the income the higher the organic kitchen waste generation, accompanied by more varied types of organic waste as well. Results show the average KOW generation in populations with high, medium and low incomes are 0.223, 0.153, and 0.103 kg/person/day. The type of organic kitchen waste that is consumed quickly is also influenced by income, which is increasing in line with higher income. This happens because of high purchasing power so that the leftover dishes are immediately discarded, while for low-income people will reheat the dish until it runs out.

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