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HOUSEWIVES' PERCEPTIONS TOWARD THE USE OF BLACK SOLDIER FLY TECHNOLOGY IN MANAGING HOUSEHOLD ORGANIC WASTE IN RURAL AREAS

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ABSTRACT
Because it produces high-value biomass. However, this technology has not been developed at the community level. Therefore, before black soldier fly technology is promoted to the public, it is important to know the public's perception of the use of this technology. The aim of this research is to analyze housewives' perceptions of the use of black soldier fly technology in processing household organic waste in rural areas, a case study in Laras Dua Village, Simalungun Regency, Indonesia. The sample size was 100 housewives obtained by Slovin equation. The first step, housewives received education and counseling about the use of black soldier flies in processing household organic waste, then continued with interviews using a Likert scale questionnaire. The results of the perception analysis showed that rural housewives strongly agreed that the use of black soldier fly technology provided technological (83.7%), economic (85.7%), and social (82.2%) benefits for rural areas. The positive perception of the technological, economic, and social benefits of using black soldier fly technology will encourage rural communities to use this technology as a sustainable household waste processing solution

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1. INTRODUCTION

Organic waste processing using black soldier fly (BSF), *Hermetia illucens* L. (Diptera: *Stratiomyidae*) has been introduced as a promising technology, especially for developing countries [1]. BSF technology can reduce waste through bioconversion of low-value organic waste to produce added-value biomass products in the forms of energy-rich larvae and nutrient-rich compost residue [2]. BSF technology engineers BSF's natural life cycle in an artificial rearing system, in which BSF larvae are fed organic waste to reduce its volume and to recycle its nutrients [3].

The life cycle of BSF depends on its feed source and the environmental conditions in which it lives [3]. The life cycle usually lasts 40–45 days starting from egg, to larva, to prepupa, to pupa, and finally to adult [4][5] (Figure 1). During the larval stage, BSF larvae can be harvested by separating them from the compost residue [3]. In the prepupal stage, BSF larvae stop eating and then start turning brownish black [6]. The larvae biomass can be harvested after 14-15 days since 5-day-old BSF larvae are fed with organic waste [4].

The application of BSF technology for waste management has several advantages compared to other composting methods. The organic waste processing method using BSF is environmentally friendly [7], this technology can reduce the weight of organic waste significantly, up to 80% less than its original weight [7][8]. The cost of building waste processing facilities with BSF is not expensive because it does not use complicated facilities [9], the waste bioconversion process is fast which can produce biomass products on the 12th day [10]. BSF technology can reduce bacterial growth thereby eliminating odors [11]. The resulting waste processing products have high economic value

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[11][12] namely BSF larval biomass products [11][13] with protein and fat content which can be used as an alternative animal feed and compost residue as biofertilizer in organic farming [8][9].

Figure 1. Black soldier fly's life cycle

The success of BSF technology application has been carried out at an industrial scale in various countries such as in South Africa, Canada, Ghana[12] several Asian countries such as China, Korea, Vietnam, Japan, and Malaysia have conducted various studies on the use of BSF technology for processing various types of organic waste such as restaurant waste, cafe waste, mixed fruit and vegetable waste, and mixed animal waste and vegetable waste to produce animal feed and biofuels [9]. In Indonesia, BSF technology has not been widely applied at a community scale; however, it has been applied at a medium industrial scale such as in a research project by Forward for waste management in wet market [4][12].

Previous studies on BSF technology focused on the species as the focus of research [12]. The social aspects of BSF technology impact on health and socio-economic aspect. Huis et al. studied the impact of BSF larvae, which is neither pest not pathogens, on human health [11]; Zewdu et al. Gracious explored BSF technology's potential to create jobs for farmers, entrepreneurs, and community members around the world, especially in developing countries [14]; and Popoff et al. discussed buyer's willingness to consume livestock fed by BSF larvae[15].

Given the success stories from previous studies and application of BSF technology [9][12], this study found the application of communal BSF technology a suitable approach for community-based waste management in rural settlements, especially in places with no organic waste processing system [9]. This research is concerned with the development of communal BSF technology for waste management in rural areas of developing countries, since this issue is often ignored from waste management discourse in most developing countries, instead giving more attention to urban waste management [16]. Previous research data reveal that 1.9 billion rural community members are not covered by waste collection services. In addition, less than 50% of rural population in 105 countries receive waste management services. Rural areas are often lacking in formal waste management services due to geographical challenges, unfavorable socio-economic conditions, and long distances from urban areas, thus requiring large transportation costs [17]. However, following population increase, as well as increase in quality and quantity of waste due to lifestyle and income changes of the villagers, the issue of inedaquate waste management system in rural areas should not be ignored [18].

Indonesia, a developing country with a population of 270.20 million people, is also experiencing major solid waste management issues [19] in its rural areas [20]. Communities in rural areas in Indonesia who have not been covered by solid waste management services usually burn or deposit their wastes via open dumping method [20]. Inadequate sanitation facilities in rural areas cause various environmental and public health problems[17][21].

Organic waste composes a majority (54%) of Indonesia's waste. Food waste make up the most common (39%) type of waste, while household is the greatest contributor (37%) of waste [20]. This paper proposes that BSF technology is worthy of promotion as a strategy for processing household organic waste in rural areas because it not only provides great potential in recycling organic waste into value-added products, but also provides innovative economic opportunities [22][23]. Therefore, prior to its mass implementation, evaluation of public perception is needed to introduce BSF technology for organic waste processing in rural areas [16]. The aim of this paper is to analyze

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housewives' perceptions of the technological, economic, and social benefits of using black Soldier fly technology in processing household organic waste in rural areas, a case study in Laras Dua Village, Simalungun Regency, Indonesia.

2. RESEARCH METHODS

This study was carried out in Laras Dua Village, Siantar Sub-District, Simalungun District, in North Sumatera Province, Indonesia (Figure 2). In 2019, the village's population was recorded at 2,779 people. Within a total area of 1030 ha, agriculture, animal husbandry, and fishery are the village's main livelihood [24]. During the time of this research, waste management facilities and infrastructures such as temporary disposal sites, garbage bins, organic and inorganic waste processing facilities, and waste transportation services were not available in Laras Dua Village. Therefore, the local community employed burning, illegal landfilling, and illegal dumping in watersheds and large ditches to deposit their waste. These inappropriate waste management methods clogged drains, polluted the agricultural fields due to waste infiltration, and caused flooding. With no intervention, this continuous mismanagement would adversely affect the village's agricultural function, environmental health, and community health. Considering this existing solid waste problem, this paper chose Laras Dua Village to be the research location.

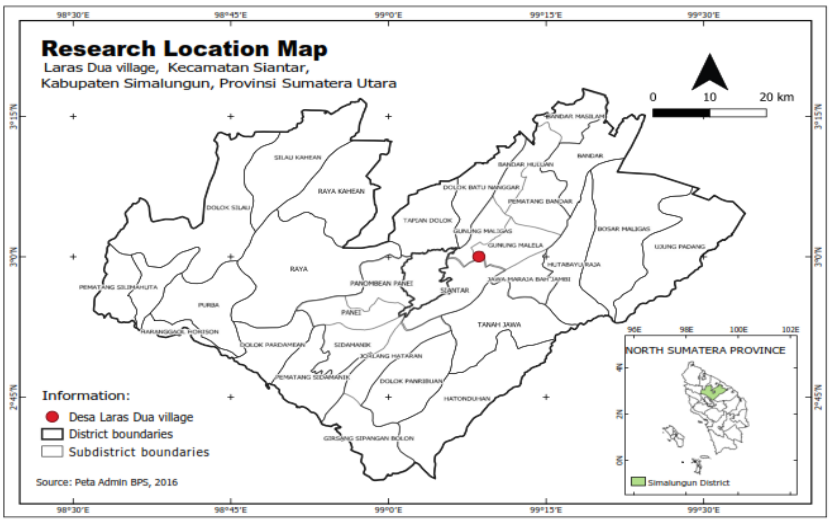

Figure 2. Study Location

The number of samples was determined by Slovin (Equation 1) [25]. At the time of this research in 2019, the total population of Laras Dua Village was 2,779 people [24]. Following this equation, the number of samples yielded 100 people.

$$n = \frac{N}{1 + N.(e^2)}$$

The respondents for this study were: housewives who were willing to be study respondents, residents who had been living in the research location for at least one year and had an identity card domiciled in the residential area of the study. This study identified housewives as the target population of this study since they were known to be directly responsible for household waste management in Laras Dua Village.

Counseling and providing education regarding waste processing using BSF technology will be carried out from August to October 2021. At this stage of the study, female participants can learn about the BSF life cycle and gain direct experience in managing communal waste processing using BSF technology. The next stage of the research was to conduct face-to-face interviews using a Likert scale questionnaire from October to December 2021 with 100 housewives who were actively involved in counseling and education. This research identifies perceptions that influence the success of implementing BSF technology in rural areas. The questionnaire questions aim to assess respondents' perceptions of the technological, economic, and social aspects of implementing BSF in processing household waste, using BSF technology communally in rural areas.

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3. RESULTS AND DISCUSSION

Result

a. Housewives' Perceptions of the Technological Benefits of Using Community-Based Black Soldier Fly in the Management of Household Organic Waste in Rural Areas.

Housewives' perceptions of the technological benefits of using community based BSF technology in managing household organic waste in Laras Dua Village are shown in Table 1.

Table 1. Housewives' Perceptions of the technological Benefits from the Use of Community-Based BSF Technology in the Management of Household Organic Waste in Laras Dua Village

No	Statement	Total Score	Perception value (%)	Interpretation
1	The use of community based BSF technology in organic waste management can be implemented in rural households	423	84,6	Strongly agree
2	The use of community based BSF technology in organic waste management can reduce the amount of organic waste in rural households	431	86,2	Strongly agree
3	Community-based BSF technology is easy to implement	404	80,8	Strongly agree
4	Community-based BSF technology for organic waste management does not require expensive costs	416	83,2	Strongly agree

The result of calculating the perception value using a Likert scale is 83.7%, which means that housewives in Laras Dua Village strongly agree that the use of community-based black soldier fly in organic waste processing provides the following technological benefits: Black soldier fly technology can be implemented in organic waste processing in rural households; Black soldier fly can reduce the amount of household organic waste in rural settlements, Black soldier fly is easy to do and not expensive to implement.

b. Housewives' Perceptions of the Economic Benefits of Using Community-Based Black Soldier Fly in the Management of Household Organic Waste in Rural Areas

Housewives' perceptions of the economic benefits of using community based BSF technology in managing household organic waste in Laras Dua Village are shown in Table 2.

Table 2. Housewives' Perceptions of the Economic Benefits of Using Community-Based BSF Technology in Managing Household Organic Waste in Laras Dua Village

No	Statement	Total Score	Perception value (%)	Interpretation
1	The use of community based BSF technology in organic waste management has added economic value	422	84,4	Strongly agree
2	The use of community based BSF technology in organic waste management can produce compost biomass products to support agricultural activities	432	86,6	Strongly agree
3	The use of community based BSF technology in organic waste management can produce BSF larvae biomass which is used as animal feed to support chicken farming and fisheries activities.	436	87,2	Strongly agree
4	There is an opportunity to sell or earn money from implementing community based BSF technology in processing organic waste.	412	82,4	Strongly agree

The result of calculating the perception value using a Likert scale is 85.1%, which means that housewives in Laras Dua Village strongly agree that the use of community-based black soldier flies in organic waste processing provides economic benefits as follows, has added economic value, can produce compost biomass products for supports agricultural activities, can produce BSF larvae biomass which is used as animal feed to support chicken farming and fisheries activities, and biomass products can be sold and are worth rupiah.

c. Housewives' Perceptions of the Social Benefits of Using Community-Based Black Soldier Fly in the Management of Household Organic Waste in Rural Areas.

Housewives' perceptions of the social benefits of using community based BSF technology in managing

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household organic waste in Laras Dua Village are shown in Table 3.

Table 3. Housewives' Perceptions of the Social Benefits of Using Community-Based BSF Technology in Managing Household Organic Waste in Laras Dua Village

No	Statement	Total Score	Perception value (%)	Interpretation
1	The use of community based BSF technology in organic waste management can be carried out by the community independently	392	78,4	Agree
2	The use of community based BSF technology in organic waste management can be carried out by village women's groups	414	82,8	Strongly agree
3	The use of community based BSF technology in organic waste management does not cause problems or conflicts in the field	396	79,2	Agree
4	The use of community based BSF technology in organic waste management can produce a clean and healthy village environment	442	88,4	Strongly agree

The result of calculating the perception value using a Likert scale is 82.2%, which means that housewives in Laras Dua Village strongly agree that the use of community-based black soldier flies in organic waste processing provides the following social benefits, can be provided by the community independently, can be carried out by groups village women, without causing problems or conflicts in the field, can produce a clean and healthy village environment.

Discussion

The use of black soldier fly larvae (BSF) is increasingly recognized in the food waste processing industry. Composting BSF larvae is preferred compared to other composting methods, because BSF larvae have a large appetite and strong mouths, and the presence of digestive enzymes to help process organic waste to produce valuable biomass products after 2 weeks from feeding BSF larvae. [26][27]. The BSF has a brief life cycle, quick development, and a promising future. BSF larvae can eat more types of organic waste and are able to reduce up to 50% of the initial waste weight [28] so that the BSF larvae composting method is more effective for processing various types of organic waste compared to other methods. The use of the BSF method is easy to implement because it does not require expensive costs [29][30], does not require large areas of land, and has simple procedures so it is easier to socialize and apply to the community [5][26].

Community acceptance will be very important to further increase the use of environmentally friendly BSF in waste processing. By comparing waste processing time and the quality of waste processing products from various existing waste processing methods, differences in processing times and types of products produced will be obtained. As a result, BSFL can be an effective option to overcome the uncontrolled generation of household waste every year, especially in developing countries. BSF larvae can be used as a substitute for animal feed to replace conventional feed whose manufacturing process is not environmentally friendly and is expensive. Nutrients discovered in waste are converted by BSF larvae into valuable proteins and lipids that are utilized as animal feed. The leftover from BSFL treatment may also be utilized as organic fertilizer. Because of the unique character of the product generated and the time required for the waste processing process, using BSF larvae eventually offers promising economic benefits [28][31][9].

Respondents in this study agreed that the application of BSF technology on a community scale for processing household organic waste can be carried out by the community in a sustainable manner. Family welfare development groups, especially women's empowerment organizations in rural areas, can include waste management activities in their programs so that they can be implemented sustainably. Previous research shows that women's participation in the informal waste processing sector and household waste processing is quite high [32]; Therefore, empowering groups of housewives in the rural waste management sector can be considered. Respondents also agreed that using BSF technology to process household organic waste can reduce the amount of waste produced, resulting in a cleaner environment considering the ability of BSF technology to process organic waste in a relatively short time environmentally friendly way [33].

BSF-based waste management can be promoted as a value-added alternative for recycling household organic waste in rural areas. The findings of this research are in line with previous research conducted by Mihai and Grozavu which stated that composting should be implemented in rural areas to overcome problems related to solid waste management [21]. In addition, the use of low-value organic waste with BSF technology can produce high-protein larvae for animal feed and nutrient-rich compost for plant nutrition, thereby not only providing an alternative solution

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for rural waste management, but also improving local livestock. and the agricultural sector which has the potential to increase local food supplies [11][34].

Laras Dua Village has the potential to develop its agricultural sector which also supports the majority of its people's livelihoods. BSF larvae and compost can be used as animal feed and organic fertilizer to support agricultural development and food security in rural areas through household food production [35]. In addition, compost is beneficial for organic farming and through independent production, practitioners can also reduce the expenditure of chemical fertilizers and maintain soil quality [35][36]. The use of compost can support organic farming to produce healthier plants for public consumption [35]. From this study, BSF-based waste processing makes a positive contribution to the environment, social quality, and livelihoods by overcoming household waste management problems, providing potential employment opportunities and potentially increasing income. These results further support Joly's previous research which stated that BSF technology can provide economic, social, and environmental benefits [12]. This study contributes to the body of literature by evaluating how rural communities perceive the use of communal BSF technology for the processing of organic waste from households. The willingness of the community to participate in waste management in rural areas is affected by views within the community.

4. CONCLUSION

This paper adds to the literature by providing an assessment of community perceptions of communal BSF technology in processing household organic waste in rural areas. Analysis of questionnaires revealed that most of the respondents in Laras Dua Village responded positively and therefore had positive perceptions of the technological, social, and economic aspects of organic waste processing with BSF technology. From the technological aspect, respondents agreed that: BSF technology could be applied on a community scale with a communal system, BSF technology could reduce the amount of household organic waste at a low cost, and communal BSF technology could be sustained by housewives. From the economic aspect, respondents agreed that: BSF technology had added economic value to household waste by producing BSF larvae and compost residue that could be used in agriculture, fisheries, and animal husbandry. From the social aspect, respondents agreed that BSF technology could be carried out by housewives the BSF technology's procurement did not cause conflict because it was implemented with mutual will and agreement. This study revealed that BSF technology can be implemented in rural areas with unresolved waste problems, does not have organic waste processing technology, has willingness to learn, and are welcoming to new technologies. This paper revealed a significant weight on BSF technology's potential as a suitable system for managing household organic waste in rural areas and as well as contributing to the development of economy in Laras Dua Village to support its agriculture, fisheries, and animal husbandry sectors. Based on the findings of this study, black soldier fly technology can be applied effectively in rural areas as a sustainable household waste processing solution and supports rural potential.

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