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BSF maggot and *Azolla pinnata* based poultry feed processing to improve the economy ressilience

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ABSTRACT

The Tirto Bakti II Farmers Group faces challenges in the poultry farming sector, including high feed prices and the need for nutritionally appropriate feed. Additionally, soybean waste in this village has not been optimally utilized. The Mahasiswa Berdesa program aims to develop poultry feed based on Black Soldier Fly (BSF) maggot, Azolla pinnata, and soybean meal with nutrients that meet poultry needs, while also improving the local economy through the sale of products derived from BSF maggot, Azolla pinnata, and soybean meal as poultry feed. The implementation method in this program includes training and mentoring in alternative feed processing. The results of this program indicate an increase in poultry feed production, with protein content reaching 12 percent and a selling price of IDR 8,400. This alternative poultry feed innovation contributes to reducing feed costs for farmers and promotes the sustainable utilization of local resources in the village. The implementation of this program has implications for increasing community capacity in feed production, creating opportunities for entrepreneurship among villagers, and encouraging the replication of similar initiatives in other rural areas to enhance local food security and economic resilience.

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1. INTRODUCTION

Sukamakmur Village, located within the Jember Regency, is predominantly inhabited by individuals engaged in agriculture and animal husbandry. Within Ajung District, this village stands out for having the highest concentration of poultry farmers, comprising 50 breeders managing over 1,000 birds. A critical factor influencing the success of poultry farming in the area is access to high-quality, nutrient-rich feed at reasonable prices. This necessity arises from the fact that approximately 60–70% of a breeder's total operating expenses are allocated to feed procurement (Harahap et al., 2024).

Nevertheless, the uncertain fluctuation in feed prices has a significant effect on production efficiency and the overall profitability of poultry farming operations (Rehan et al., 2025). To address this challenge, the development of alternative poultry feed that is both nutritionally balanced and economically viable is essential to enhance farm productivity and support sustainable growth. According to Edi (2021), alternative feed refers to a substitute for commercially produced feed that offers comparable nutritional

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value. This type of feed presents a practical solution, as it utilizes locally sourced ingredients and a more straightforward manufacturing process, ultimately leading to reduced production expenses.

The Tirto Bakti II Farmer Group, under the guidance of the Ajung District Agricultural Extension Center, has partnered with the Faculty of Agricultural Technology at the University of Jember to establish a maggot cultivation enterprise. This initiative includes the development of several derivative products such as dried maggots, organic fertilizers enriched with fermented cow manure and kasgot, liquid organic fertilizers, and catfish feed. Despite the relatively rapid progress achieved through the collaboration between academic institutions and the farmer group, the resulting products have yet to deliver widespread benefits to the broader Sukamakmur Village community, particularly among local poultry farmers. The poultry feed product, derived from maggots, represents a novel venture for the Tirto Bakti II group. With maggot yields reaching approximately one ton per month and no prior development of maggot-based poultry feed alternatives, there exists considerable potential for utilizing this resource to enhance the sustainability and efficiency of local poultry farming. Consequently, it is essential to further develop maggot-derived products that specifically address the needs of both the Tirto Bakti II group and poultry farmers in Sukamakmur Village.

The Village Student Program (PROMAHADESA) is a funding initiative aimed at supporting the development of village-based potential projects in the surrounding areas of the University of Jember. One of its key initiatives involves the creation of alternative poultry feed made from maggot-based products, formulated by combining *Azolla pinnata* and soybean meal— a solid by-product from a soybean processing facility located in Sukamakmur Village. This empowerment program is carried out in collaboration with local farmers who are members of the Tirto Bakti II Farmer Group, enabling them to actively engage in the production and innovation of alternative poultry feed. Through this partnership, farmers gain knowledge and practical skills in producing nutritionally balanced feed using locally available, cost-effective ingredients that meet poultry dietary requirements. A primary concern in poultry feed formulation is the availability of reliable protein sources (Harahap et al., 2024). Therefore, ingredient selection is primarily based on protein content. Maggots are known to contain approximately 42% protein and fat, moisture content between 64.86-74.44%, and ash content between 2.88-4.65% (Indariyanti & Barades, 2018; Azir et al., 2020). Soybean meal offers around 51.9% protein and *Azolla pinnata* contributes 24–30% protein along with essential minerals vital for poultry development (Saroh et al., 2019; Daud et al., 2022). BSF (Black Solder Fly) larvae or commonly called maggots have a chewy texture and have the ability to secrete natural enzymes so that they can be used as additional feed for farm animals because if there are feed ingredients that were previously difficult to digest, they can be simplified and can be used by farm animals (Afkar et al., 2020). Beyond their nutritional advantages, these ingredients help minimize production costs, offering a more affordable alternative to commercial feed. The incorporation of maggots, *Azolla pinnata* R. Br., and soybean meal is therefore viewed as a promising, nutrient-rich, and cost-effective solution for poultry feed.

This program is designed with two primary objectives: (1) To formulate poultry feed utilizing Black Soldier Fly (BSF) maggots, *Azolla* plants, and soybean meal, ensuring the nutritional composition aligns with the dietary requirements of poultry; and (2) To enhance the local economy by increasing the market value of products derived from the use of BSF maggots, *Azolla*, and soybean meal as alternative poultry feed.

2. METHODS

Design, Time, Location, and Implementation Target

The implementation framework for this Village Student Program consists of a series of community service-oriented activities that emphasize direct community involvement. This is achieved through

educational outreach, counseling sessions, and skill-building initiatives focused on transforming the products of Black Soldier Fly (BSF) maggot cultivation, residual by-products from tofu and tempeh production, and *Azolla pinnata* plants into poultry feed. These efforts aim to contribute to the economic advancement of the Tirto Bakti II Farmer Group and the broader community of Sukamakmur Village. The detailed program structure is illustrated in Figure 1. Scheduled for execution between July and August 2024, the program will take place in Langsatan Hamlet, Sukamakmur Village, within the Ajung District of Jember Regency. The intended participants include 40 individuals from the Tirto Bakti II Farmer Group, along with local village officials.

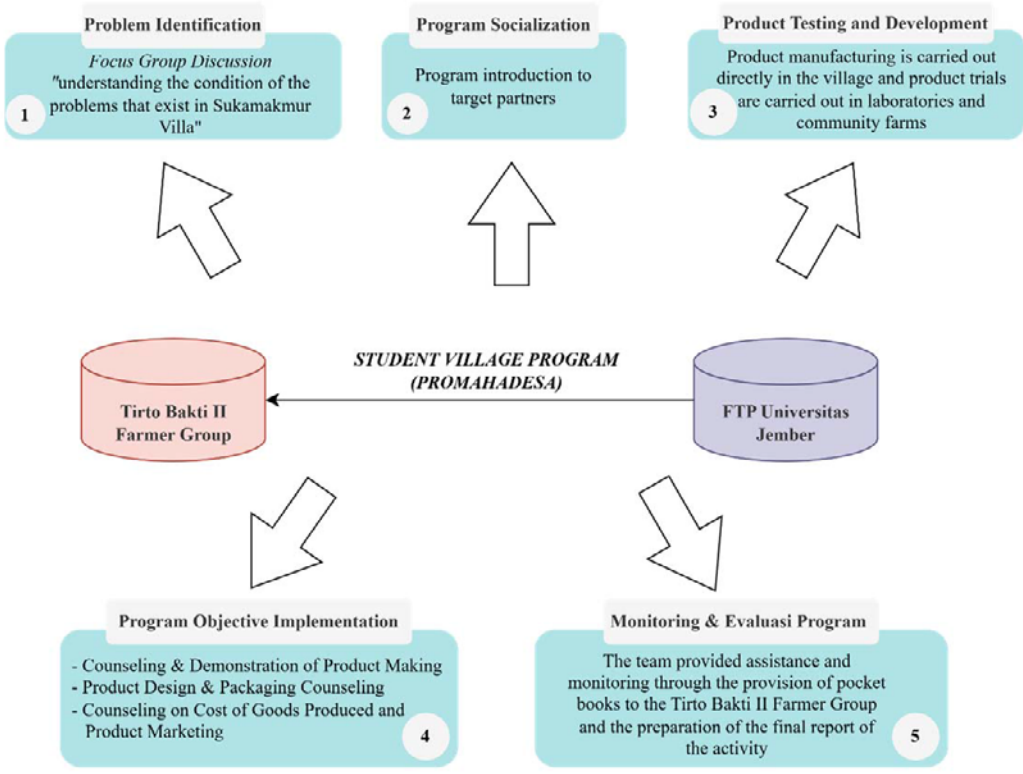

Figure 1. Program implementation design

Materials and Tools

The primary materials utilized in the production of poultry feed products consist of Black Soldier Fly (BSF) maggots, *Azolla pinnata*, rice bran, and soybean meal. To support the feed manufacturing process, a range of equipment is employed, including a pellet molding machine (see Figure 2), as well as various tools such as buckets, stoves, frying pans, spatulas, sieves, baking pans, ovens, blenders, gloves, digital scales, and sealing devices. These tools facilitate each stage of production, from material preparation to final packaging.

Evaluation Design

The success of this alternative poultry feed development initiative is measured through several key targets and indicators. These include the successful implementation of the production process for

poultry feed based on BSF maggots and *Azolla pinnata* in collaboration with farmer groups, an increased understanding among farmers regarding the nutritional and functional value of each feed ingredient, and the ability of the Tirto Bakti II Farmer Group to independently produce and market the alternative feed product. To ensure the sustainability and effectiveness of these outcomes, follow-up activities are essential. Specifically, monitoring and evaluation processes aimed at assessing overall program progress and summarizing key results achieved during implementation. Even if the facilitator no longer plays an active role or the service activities have ended, these post-service activities must still be able to provide opportunities and support for the community to continue empowerment through the role of stakeholders (Sudarmanto et al., 2020). In addition, the feasibility of a service program is also seen from its continuous implementation by adjusting the development and target needs of the activities carried out (Emilia, 2022).

Table 1. Methods and stages of activities

Activity Time	Activities Activities	Activity Objectives
1st Meeting	- Introduction to the program - Introduction to the implementing group - Introduction to the equipment to be used - Introduction to examples of products to be made during the program implementation	- Explaining the community service program to be implemented - Introducing the group that will carry out the mentoring - Introducing the product to be made - Providing an introduction to the equipment used
2nd Meeting	- Assistance in selecting materials to be used - Assistance in processing procedures before printing	- Accompanying farmer groups in selecting raw materials for making poultry pellets - Accompanying farmer groups in processing maggots and other materials before mixing
3rd Meeting	- Explanation of formulation and method of making poultry pellets - Mentoring in making poultry pellets	- Explaining to farmer groups regarding poultry pellet formulations - Accompanying farmer groups in poultry pellet production activities
4th Meeting	- Introduction to types of packaging and product labels - Mentoring in product packaging and label design - Mentoring in product packaging methods	- Introducing types of product packaging and labels - Accompanying the creation of product packaging and label designs - Accompanying product packaging methods
5th Meeting	- Introduction to potential marketplaces for product sales - Mentoring in product marketing activities	- Introducing potential marketplaces for placing products that are currently popular with the general public - Accompanying product marketing activities
6th Meeting	- Monitoring the selection of poultry pellet production materials - Monitoring poultry pellet production activities - Monitoring poultry pellet product marketing activities	- Monitoring the selection of materials so that the selection of materials is appropriate and maintains the quality of the pellets - Monitoring production activities so that they are in accordance with SOP - Monitoring marketing activities for poultry pellet products
7th Meeting	- Providing closing remarks and gratitude to all elements that have contributed - Review of product results	- Giving farewell to all elements that have contributed as well as partners and showing the results of the implementation of the community service program

Figure 2. Poultry feed making machine

This initiative was carried out collaboratively by the program implementation team and members of the Tirto Bakti II Farmer Group. Through post-implementation activities, changes in both the quantity and quality of poultry feed production, as well as shifts in market demand, were assessed. As part of the training process, a module was developed to serve as a practical guide for the Tirto Bakti II Farmer Group, enabling them to better understand the application of BSF maggots and *Azolla pinnata* as alternative components in poultry feed. The module, titled "Poultry Feed Revolution: The Benefits of BSF Maggots and *Azolla pinnata* for Modern Livestock" provides detailed information on the feed products, raw materials, production procedures, and the nutritional benefits of each ingredient. Furthermore, the characteristics of the feed formulations were evaluated qualitatively, based on outcomes observed in each composition, to identify the most effective formulation.

3. RESULTS AND DISCUSSION

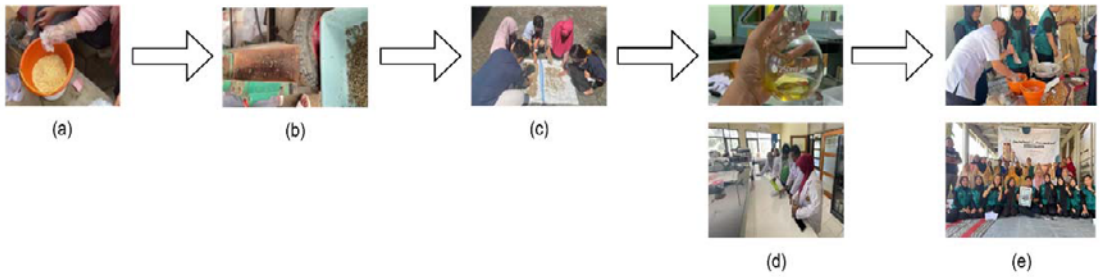

Figure 3. Series of implementation of program activities

The implementation of this program involves a series of structured activities, which include: (a) Selecting appropriate raw materials for poultry feed formulation; (b) Shaping the feed into pellets through a molding process; (c) Drying the feed to ensure proper storage and preservation; (d) Conducting nutritional analyses, specifically testing for protein and fat content; and (e) Delivering educational sessions and live demonstrations to participants. These stages are illustrated in Figure 3.

Material Selection

The selection of raw materials plays a vital role in the production of poultry feed, particularly in achieving an optimal balance of nutrients necessary to support the growth, health, and productivity of

poultry. Essential nutrients required by poultry include proteins, fats, fibers, minerals, vitamins, and water (Barszcz et al., 2024). In this community service initiative, the choice of ingredients was informed by prior research conducted by Allaily et al. (2024), which demonstrated that feed formulated with *Azolla pinnata* and BSF maggots can effectively replace up to 20% of commercial feed without negatively impacting egg quality. The primary raw materials used in this program's feed formulation include BSF maggots, *Azolla pinnata*, rice bran, corn flour, tofu dregs, corn rice, soybean meal, and soybean flour. The feed formulation process and experimental trials are illustrated in Figure 4.

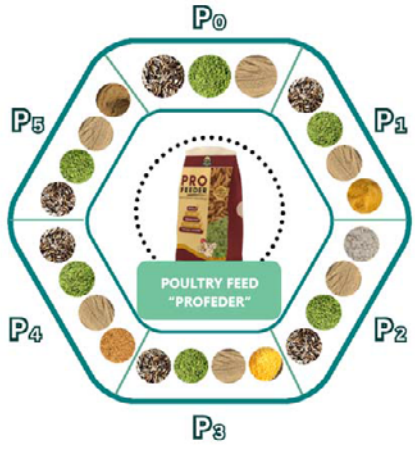

Figure 4. Poultry Feed Ingredients Formulation (P0: BSF Maggot, *Azolla pinnata*, rice bran; P1: BSF Maggot, *Azolla pinnata*, rice bran, corn flour; P2: BSF Maggot, *Azolla pinnata*, rice bran, tofu dregs; P3: BSF Maggot, *Azolla pinnata*, rice bran, corn rice; P4: BSF Maggot, *Azolla pinnata*, rice bran, soybean meal; P5: BSF Maggot, *Azolla pinnata*, rice bran, soybean flour)

Product Development

Product development begins with the selected and formulated materials, then continues with drying techniques through drying. The process of drying feed materials is an important process in the manufacture of animal feed. This aims to reduce the moisture content of the material so that the final product will be of high quality and durability. The reduction in moisture content can also facilitate processing and distribution, which has a positive impact on increasing added value and selling prices (Tanggasari & Jatnika, 2023). The evaluation of each formulated poultry feed was conducted by assessing its physical attributes, including color, aroma, shape, and texture. These characteristics served as indicators for identifying the most suitable formulation, as detailed in Table 3. The results indicate that the optimal feed quality was observed in formulations P0, P4, and P5. These three variants demonstrated physical traits aligned with standard poultry feed quality, specifically a consistent brown coloration and an absence of fungal contamination. High-quality feed typically emits a fresh, non-rancid aroma. In contrast, an unpleasant or pungent smell may indicate elevated moisture content, which can promote microbial activity and spoilage (Utama et al., 2020). The table below presents a comparative analysis of the physical characteristics of five alternative feed formulations that were tested on laying hens.

Final Product Testing

The most promising feed formulation was further evaluated based on the standards outlined in SNI 8290-6:2024, which specifies three key parameters: moisture content, crude protein content, and

crude fat content. According to this standard, the maximum allowable moisture content for both Grade 1 and Grade 2 feed is 13%. The minimum crude protein content is set at 16% for Grade 1 and 15% for Grade 2, while the minimum crude fat content required for both grades is 3%. Among the formulations tested, the highest quality feed was found in formulation P4, which comprises BSF maggots, *Azolla pinnata*, rice bran, and soybean meal. This alternative feed demonstrated a nutritional profile of 12% crude protein and 16% crude fat. In terms of physical properties, the feed exhibited a brown color, consistent pellet shape and size, a coarse and porous texture, and a moisture content of 5%.

Table 3. Physical characteristics of the formulation of poultry feed products

Formula	Characteristics			
	Colour	**Form**	**Aroma**	**Texture**
P_0	Pale brown	Pellet, similar	Maggot and rice bran	Congested, smooth
P_1	Pale brown	Pellet, similar	Maggot and rice bran	Congested, a bit rough
P_2	Very pale brown	Pellet, dissimilar	Maggot and tofu dregs	Soft, smooth, sticky, not palatable
P_3	Golden brown	Pellet, dissimilar	Maggot and corn rice	Rough, crumbly
P_4	Yellowish brown	Pellet, similar	Maggot and soybean	Rough, porous
P_5	Grayish brown	Pellet, similar	Soybean	Soft, smooth

Socialization

The socialization phase of the program involves disseminating information about the potential of maggot cultivation and the utilization of local waste materials, along with the processes involved in converting these resources into value-added products such as poultry feed. The primary objective of this initiative is to enhance the awareness and understanding of the Sukamakmur Village community regarding the untapped potential within their own environment. By doing so, the program aims to stimulate the development of new entrepreneurial opportunities and support efforts to improve the village's overall economic well-being (Nurkholis, 2020).

Activity Achievements

The community service program successfully engaged over 40 residents, including both administrators and members of the Tirto Bakti II Farmer Group. Throughout the program, participants actively contributed to each activity. Notably, the program resulted in the creation of a highly nutritious product, containing 12% protein and 16% fat, with a market price of IDR 8,400, alongside several other advantages derived from the development of maggot cultivation and waste processing in Sukamakmur Village. As a result, the program provided tangible benefits by optimizing poultry feed production and reducing reliance on commercial feed, thus offering a formulation that meets the nutritional standards for poultry while increasing farmers' income. Additional advantages include the enhancement of participants' knowledge and skills, as well as the successful implementation of feed formulations with higher economic value, supported by educational sessions and counseling throughout the program.

4. CONCLUSION AND RECOMMENDATIONS

The BSF Maggot and *Azolla pinnata*-based poultry feed processing program represents an innovative alternative that produces animal feed with optimal nutrient content to meet poultry needs. The blend of ingredients used in this feed formulation ensures high nutritional value, enhances feed

cost efficiency, and maximizes the use of abundant local resources. The resulting poultry feed contains 12% protein, 16% fat, and 5% moisture. This program has yielded positive outcomes for farmer groups and poultry farmers, as the feed products have been successfully adopted by farmers. Additionally, it contributes to the economic improvement of the community by promoting poultry feed innovation and facilitating effective organic waste management practices

Based on the outcomes of the community service activities, several suggestions and recommendations can be made, such: (1) It is essential to establish cooperation and partnerships with various sectors, including local governments and private entities, to facilitate the introduction and promotion of the products to a wider audience. Such collaborations can also aid in securing regulatory support, gaining access to funding, and ensuring ongoing coaching. Additionally, partnerships with research institutions, such as universities, can play a key role in advancing further development and innovation in the formulation of poultry feed for livestock; (2) While the poultry feed produced in this initiative has shown promise, it has not yet undergone testing for shelf life. Therefore, it is recommended to conduct shelf life testing to assess the product's durability and ensure its long-term effectiveness.

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