



## Postharvest Handling of Coffee through Coating Application with Zero-waste Concept to Support Green Economy in Wanagiri Village, Sukasada District, Bali

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### ARTICLE INFO

#### Article History:

Received: 20 June 2024

Final Revision: 7 July 2024

Accepted: 16 July 2024

Online Publication: 22 August 2024

### KEYWORDS

Coffee, coating application, cultivation, postharvest, GMP, SSOP

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### ABSTRACT

The objective of this activity is to enhance the knowledge of the community in Wanagiri Village on more effective and efficient coffee farming techniques, to improve the productivity and quality of life for coffee farmers in the area. The training will focus on developing skills in coffee cultivation, postharvest processing, and product diversification. The specific type of coffee being highlighted is robusta Wanagiri coffee, which has gained international popularity due to its unique aroma and flavor. The planned activities will include face-to-face training, counseling, and hands-on practice, where experts will provide guidance and support to help the partners understand and apply the technology provided. The ultimate goal is to enable the partners to improve their coffee production and develop diverse coffee products, such as ground coffee, green bean coffee, and instant specialty coffee, to reach a wider market. This activity is scheduled to take place in Wanagiri Village, Sukasada District, Buleleng Regency on August 5th, 2024. After the training and exercise, it was found that the participants understood the material presented by the resource person and were very interested in applying a coating to their coffee to reduce farmer losses and to utilize or process coffee husk waste into animal feed to be fed directly to their livestock or to become organic fertilizer. Good postharvest handling, including the application of coating technology, is very important in maintaining coffee quality, particularly in preserving aroma and flavor during storage and transport. In addition, the application of zero-waste technology in coffee processing has the potential to reduce waste and increase the value of coffee by-products.

## 1. INTRODUCTION

### 1.1. Research Background

Coffee is one of the plantation commodities that has a high economic value and plays an important role as a source of foreign exchange. Coffee is known as a functional food because it contains antioxidant compounds and has radical scavenger activity [1]. Indonesia is the fourth largest coffee exporter after Brazil, Vietnam, and Colombia [2]. The proliferation of cafés that

serve coffee-based food and drinks is one of the drivers of the coffee plantation business. On the other hand, Indonesian coffee plantation products are recognized as having comparative advantages in the international market so the opportunity for Indonesian products to enter the international market is quite wide open. The green economy program is an effort to realize sustainable economic growth, job creation, and poverty reduction in Indonesia [3]. A green economy can also be defined as an economy that produces low/no carbon dioxide emissions to the environment, saves natural resources, and has social justice [4]. A systematic approach with concrete steps is needed to accelerate



the growth of the green economy in Indonesia. One of the efforts to achieve this is through village community empowerment, which is an effort to develop community independence and welfare by increasing knowledge, attitudes, skills, abilities, and awareness of utilizing resources. This can be done through the establishment of policies, programs, activities and assistance that are by the essence of the priority problems of community needs [5]. Village Community Empowerment under RO Law Number 6 of 2014 is an effort to improve the quality of life and life and welfare of the village community [6]. Bali is known as one of the coffee producing areas that is very well known abroad, especially Buleleng Regency. In accordance with the regional regulation of Buleleng Regency on the Regional Medium-Term Development Plan of Buleleng Regency 2023-2026, it is stated that the potential of 3 superior plantation products of Buleleng Regency include coffee, cloves, and vegetables.

Coffee production reached 728.49 tonnes per year, clove production as a crop that is currently considered to have high potential only reached 12.75 tonnes per year, and vegetable production reached 56 tonnes per year. The National Priority Project for Buleleng Regency is the development of a plantation area of 20,274Ha with a total funding indication of 5.5 billion rupiah, through the Ministry of Agriculture's program to increase the production of sustainable plantation commodities. The potential of Buleleng Regency is in agriculture, livestock, fisheries, trade, and tourism. The existence of the national road as the axis road of the regency provides support for high accessibility to spur the potential of the region to improve welfare.

From a geographical perspective, Sukasada Sub-district is one of the sub-districts in Buleleng Regency that has a very strategic location [7]. This is because Sukasada is a sub-district located at the southern end of Buleleng Regency. In addition, Sukasada District is the main link for all activities, especially economic activities, between Tabanan Regency and the capital of Buleleng Regency, namely Singaraja City. In the west, it is directly adjacent to Kecamatan Banjar. As a result of this geographical location, Kecamatan Sukasada, with an area stretching from north to south, has the potential to develop various businesses. Such as agriculture, trade, industry, and services by utilizing the local potential of the local community.

The local potential of Sukasada Sub-district encompasses a range of economic activities, including agriculture, plantations, livestock farming, and fisheries. This potential has experienced significant growth and development, largely due to the favorable geographical conditions that support it. The majority of Sukasada sub-district is situated in the highlands, while the administrative centre is located in the lowlands. The Sukasada Sub-district is home to the highest point in Buleleng Regency, namely the peak of Bukit Tapak (1903m), as well as Lake Buyan (360ha). Furthermore, a comparison between the dry and rainy seasons reveals no significant differences. It is a matter of fact that the rainy season in the Sukasada sub-district is no different from the rainy season in other sub-districts in the Buleleng district. Rainfall is distributed relatively evenly throughout the year, with temperatures ranging from 20 to 24 degrees Celsius. The Sukasada subdistrict encompasses 14 villages and one neighborhood, covering a total area of 172.93 km<sup>2</sup>. The subdistrict is predominantly agricultural, with a particularly conducive environment for dry farming of coffee plants. The

presence of comprehensive agricultural facilities and infrastructure enables optimal agricultural production.

Wanagiri Village, which is known as an ecotourism destination, has a variety of potential commodities that need to be developed, one of which is coffee. Following the Wanagiri Village RPJM 2020-2025, the highest potential plantation yield is coffee, which is 728.49 tonnes, followed by cloves at 12.75 tonnes and vegetables at 56 tonnes. The tourism potential in Wanagiri Village opens up opportunities for the presence of various community activities that support tourism activities, namely 3 waterfall tours, including Banyu Wana Amertha, Banyumala, and Pucak Manik waterfalls, tracking and glamping areas. One of them is coffee cultivation activities that can support its availability and can be offered to visitors or tourists. All the potential that exists in Wanagiri Village needs to be developed with assistance involving several active groups to increase their knowledge, skills, and independence, such as the Jagra Wana Farmer Group and the Leket Sari Farmer Group. As one of the villages directly adjacent to the Buleleng forest, the main livelihood of the community is from agriculture, especially coffee plantations, and also animal husbandry. The location is rather far from the crowd so that the activities are only the community around the area involved [8].

In Wanagiri Village, two farmer groups are in operation. The Jagra Wana Forest Farmer Group (KTH) is located in Bhuanasari hamlet and is chaired by Ketut Arta. It was established in 2015 and has 37 members. The other group is the Leket Sari Farmer Group, which is located in Yeh Ketipan hamlet and is chaired by Ketut Ngembeng. It was established in 2000 and has 30 members. The group's location adjacent to the Buleleng forest renders it remote and relatively isolated from the wider community, particularly in terms of access to various skills and resources. Due to its remote location and proximity to the Buleleng forest, the group is in urgent need of assistance to effectively manage its coffee plantation and postharvest operations. The lack of support hinders the group's ability to generate income, limiting its potential for growth and development. The acquisition of these skills will not only enhance the group's capacity to manage its plantation and postharvest activities but also equip members with the knowledge and expertise to start their own businesses, thereby diversifying their income sources and enhancing their financial autonomy.

The implementation of postharvest technology in the context of smallholder agriculture encompasses a range of strategies and techniques. 1) There is a paucity of knowledge among farmers with regard to the technology required for the management of coffee plantations. 2) There is a paucity of knowledge among farmers regarding postharvest handling techniques to prevent the formation of mould in coffee products. 3) Limited access for farmers to coffee processing technology. 4) A paucity of interest among farmers in adopting technological solutions for coffee plantations. 5) Farmers often find themselves in a weak bargaining position with regard to buyers, which results in the sale of low-quality ground coffee. In light of these challenges, adopting and utilising postharvest technologies is paramount for smallholder farmers to facilitate their integration into the agricultural value chain. In order to ensure long-term sustainability, it is essential to facilitate the growth of rural agro-industries. This can be achieved by supporting the development of these industries and providing guidance and mentorship to empower individuals in rural communities. This approach can

create employment opportunities in a range of sectors, including postharvest handling, packaging, processing, transportation, and marketing. Furthermore, the expansion of rural agro-industries can have a significant impact on global economic development and poverty alleviation, both in rural and urban areas [1].

Agro-industry can also reduce poverty, especially in rural areas [10]. The development of postharvest handling of coffee plantation crops is carried out to increase the competitiveness of superior products whose potential is significant enough to improve the economic strength of the people in rural areas [11]. The goal is to reduce yield or postharvest loss due to physical loss and shrinkage, quality improvement, and added value of agricultural products. Postharvest handling of coffee is carried out from the picking process to the process that produces intermediate products. Postharvest activities include harvesting, collecting, peeling, washing, sorting, drying, grading, packaging, storage, and transport [12]. The application of postharvest technology for coffee plants is still uneven. This is due, among other things, to the fact that the dissemination of information about postharvest technology has not been carried out intensively. The government's attention to increasing the added value of coffee plantation commodities in rural areas has been relatively small when compared to efforts to improve the production of agricultural products through crop cultivation. Therefore, the development of postharvest handling until now is still slow and not in line with expectations [11]. The role of postharvest technology in the coffee agro-industry is still limited to stripping the outer skin and drying naturally [13].

Collectors and large-scale entrepreneurs improve global market competitiveness by implementing internationally accepted standardization. Implementation of standardization at the smallholder level cannot be done on a mass scale, given the limited knowledge and low bargaining power of farmers. Standardization is realized through agreements determined by sellers and buyers so that criteria or requirements appear in determining prices [14]. Increasing the added value of agro-industrial products in the global market, especially for coffee plantation crops, cannot be separated from compliance with quality standards that apply worldwide. Currently, the implementation of Indonesian quality standards related to agricultural products at the national level is also being promoted. Therefore, the application of standardization to both raw (fresh) and processed products, as well as to processes and equipment, will increase competitiveness in domestic, regional, and global markets. Globalisation of marketing will have an impact on increasing the income of the agricultural sector and the performance of the national economy, through strengthening and improving the competitiveness of national agricultural products [15].

The implementation of Indonesian National Standards (SNI) is carried out to protect consumers, producers, and traders, and to save foreign exchange in Buleleng. The implementation of SNI must be based on consumer pull, so socialization must start from consumer awareness of the meaning and benefits of SNI. It is necessary to explain the benefits of SNI for traders and farmers/producers. Structural implementation of SNI by involving institutions and stakeholders must be supported by rules that provide incentives to use SNI as a quality-determining factor. SNI is a product-based certification, not a process, so its implementation is more implementable. Therefore, adequate institutions and test facilities are needed. The agro-industry

development, which adds value to agricultural commodities, is the basis for the government to continue using postharvest technology as a policy instrument for agro-industry development. This condition is expected to be a way to improve the welfare of the farming community.

The re-strengthening of the agricultural sector is achieved through the revitalization of agribusiness development and farmer welfare improvement programmes. The Rural Agribusiness Enterprise Programme (PUAP) is implemented through the establishment of centres and the development of superior commodity agribusiness areas in the regions. The farmer welfare improvement programme is conducted through the increased empowerment of extension services, mentoring, business guarantees, price protection, protection policies, and other promotional activities [2].

## 1.2. Literature Review

### 1.2.1 Coffee

Coffee plants (*Coffea* spp.) are one of the most economically critical tropical crops, especially in coffee-producing countries such as Indonesia [17]. In the world, there are more than 100 species of coffee, but *Coffea arabica* (arabica coffee) and *Coffea canephora* (robusta coffee) are the two most widely cultivated species. Arabica coffee is usually grown in areas with an altitude of 1,000 to 2,000 meters above sea level and has a more subtle flavor than robusta, which is more resistant to disease and can grow at lower altitudes [18]. In Bali, coffee plants, especially the arabica type, are widely cultivated in mountainous areas such as Wanagiri Village. The climatic conditions in this area are very favorable for the growth of premium-quality coffee. In addition, the agroforestry approach applied by local farmers also helps maintain the sustainability of the local ecosystem. However, to maintain optimal coffee production, good management is required from cultivation to postharvest [19].

### 1.2.2 Harvest and Postharvest of Coffee

The coffee harvesting process is an important stage that significantly affects the product's final quality. Choosing the right harvest time, when the coffee fruit is fully ripe, determines the flavor of the coffee produced. Typically, coffee cherries are selectively harvested by hand, which allows farmers to pick only fully ripe cherries. However, this method is also labor-intensive and time-consuming [20]. After harvesting, coffee must immediately go through the postharvest process, which includes peeling, fermentation, washing, drying, and storage. Each of these stages plays an important role in maintaining coffee quality. For example, proper fermentation can remove the mucilage layer from coffee beans, which greatly affects the flavor of the coffee. Drying is also very important as poorly dried coffee beans can be susceptible to mold infestation that damages the quality [21]. Therefore, the use of innovative technologies in the postharvest process can improve the quality of the coffee produced.

### 1.2.3 Coating Application on Coffee

Coating application on coffee beans is one of the innovative technologies used to extend the shelf life and maintain the quality of coffee. Coating is the process of coating coffee beans with natural materials that can prevent the entry of oxygen and microorganisms, which can cause damage to coffee beans. Some frequently used coating materials include chitosan, beeswax, and various plant extracts with antimicrobial and antioxidant

properties [22]. Research shows that chitosan-based coatings are highly effective in reducing microbial growth on coffee beans and preventing oxidation that can damage the coffee flavor. In addition, the coating also helps to maintain the moisture of the coffee beans, so that the beans stay fresh longer during storage [23]. With the application of this technology, the coffee produced can compete better in the global market, while supporting environmentally friendly sustainable agricultural practices.

### 1.2.4 Implementation of Zero-Waste Technology

The zero-waste concept in the coffee industry is an approach that aims to reduce waste and optimize the efficient use of resources. In the context of coffee farming, zero-waste technology includes various initiatives such as processing agricultural waste into value-added products. For example, coffee fruit skin waste can be processed into organic fertilizer or alternative fuel, which not only reduces waste but also adds economic value to farmers [24].

The implementation of zero-waste technology in Wanagiri Village has great potential to support a green economy in the area. This technology can provide long-term economic and environmental benefits by minimizing environmental impacts and creating a more sustainable production cycle. In addition, this approach can also improve production efficiency and reduce operational costs, which supports the well-being of the local community [25][26].

### 1.3. Research Objective

This study aimed to improve the quality of coffee production and community knowledge. Various efforts were made, such as training on cultivation and postharvest processing according to GMP and SSOP standards to prevent product damage, including the use of coating applications. Training also focused on efficient farming techniques, product diversification such as ground coffee and green beans, and processing coffee waste into value-added products. In addition, coffee business management skills improvement and entrepreneurship training including digital marketing strategies were conducted to expand the market and increase sales.

## 2. MATERIALS AND METHODS

The planned method of implementing PM-UPUD activities for the Jagra Wana Farmer Group and the Leket Sari Farmer Group in Wanagiri Village, Sukasada District, Buleleng Regency is using:

- a. The face-to-face method provides counseling, training, and hands-on practice so that partners gain knowledge about the management of cultivation, postharvest, and coffee processing.
- b. Direct practice, guided by competent instructors, so that partners can apply the technology provided and handle problems in handling post-harvest coffee.

Stages or steps in implementing the solutions offered

The stages or steps in implementing the solutions offered in the PM-UPUD activity Postharvest Handling of Coffee Through Coating Applications with the Concept of Zero-waste to Support Green Economy in Wanagiri Village, Sukasada District, Bali are as follows:

1. Literature study: the required literature is knowledge about postharvest handling and processing of robusta coffee products as well as knowledge about natural preservatives or

coatings and their application methods, packaging, entrepreneurship, coffee skin waste for animal feed and organic fertilizer, coffee management and marketing so that the products produced have added value.

2. Analyze the community situation: This is a significant beginning because community service starts with the intention to help the community. This stage is carried out in two sub-stages: the first determining partners, the wider community, certain communities, specific audiences or organizations, and certain people in society. The second is to determine the problem areas to be analysed, which include comprehensively, which means trying to find see and study the whole problem faced by partners. This requires a multidisciplinary approach. It can also be limited, meaning that it is only limited to two problem areas. The situation analysis to be carried out is to observe the process of handling coffee postharvest, coffee quality and shelf life, packaging, entrepreneurship, and marketing carried out by partners, the production equipment used, and the business management carried out.
3. Problem identification: The results of the analytical work covering the targets and problem areas can be found and then the problems faced by the selected target group can be formulated. The targets will be addressed in this stage through PM-UPUD community service activities later.
4. Determine specific work objectives. At this stage, it can be determined which new conditions will be produced through service activities later. In other words, what changes will be desired to make the work objectives more straightforward.
5. Problem-solving plan. The problem that has been identified needs to be solved, and the goals set must be achieved simultaneously by looking for alternative solutions to the problem and choosing the best one.
6. Social approach. The principle is that the target community is the subject and not the object of this community service activity. For this reason, it is attempted to involve the community as much as possible, by trying to approach and make them realize that the problems formulated above must be solved. Furthermore, if they are unable, this is where the implementers and universities take a role to improve partners' lives.
7. Activity Implementation. Before the implementation of the activity, a work plan is first prepared which includes determining how the activity will be carried out, determining the time of implementation, determining the place of implementation, and determining the people who will be involved in the activity.
8. Evaluation of activities and results. Each stage must be evaluated to move to the next stage, which requires improvement during the activity process. No less critical is the evaluation of the results or impact of all community service activities, so that not only knowing what the results of activities have been but also learning how to know and measure the changes that have occurred. This evaluation will produce a form of accountability for everything that has been done before. This evaluation's results are crucial in terms of administrative completeness and being known by everyone involved, including the target community.

### 3. RESULT AND DISCUSSION

#### 3.1. Fertilisation and pruning

In addition to fertilizing, pruning is another essential aspect of blooming plant care. Pruning helps maintain plant shape, remove dead or diseased growth, and promote air circulation and light penetration, crucial for overall coffee plant health and flower production. 20 participants attended training on fertilization and pruning in coffee cultivation. Based on Graph (a), before the training, all participants had taken care of the coffee plants but not optimally. Participants who fertilized coffee were only 35%, and those who pruned were only 30%. The utilization of coffee waste into fertilizer was only known by 65% of the total number of participants who attended the training. Pruning and fertilization significantly affect the production of coffee trees. After the training, it was found that the participants understood the material presented by the resource persons and were very interested in implementing it on their coffee farms.

#### 3.2. Coating application on Coffee

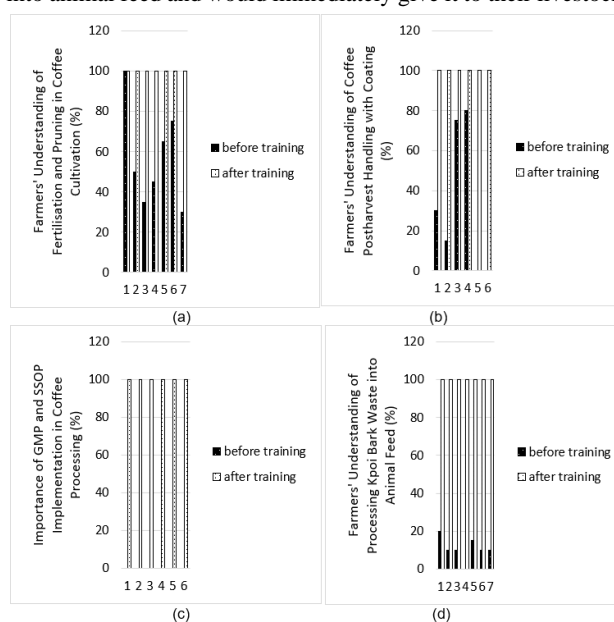
Coffee is known worldwide for its distinct aroma and flavour resulting from several volatile compounds. It is very difficult to arrest the aromatic compounds once the roasting process is complete and it becomes even more challenging to store the beans for a longer time with the retained volatiles as these compounds are easily lost during industrialized processing such as the grinding of roasted coffee beans and storage of ground coffee[3]. Thus, an attempt was made to minimize the loss of volatility from roasted coffee beans by coating. Based on Graph (b), before the training, all participants did not know about the coating. Participants experienced problems in processing coffee. 80% of the participants who attended the training experienced moldy coffee during drying. The coating method can help farmers to keep sun-dried coffee from growing mold. After the training, it was found that participants understood the material presented by the resource person and were very interested in applying coatings to their coffee so that it would reduce farmers' losses. The training on coffee postharvest handling with coating was attended by 20 participants.

#### 3.3. GMP and SSOP

GMP (Good Manufacturing Practice) is a guideline or set of procedures for processing food products to produce safe and high-quality products for consumers. SSOP (Standard Sanitation Operating Procedure) is a sanitation standard that ensures an organization's optimal implementation of GMP. Based on Graph (c), all participants did not understand GMP and SSOP before the training. Applying GMP and SSOP during production dramatically affects the quality of the coffee produced. Based on the pre-test results, training on GMP and SSOP was conducted. After the training, it was found that the participants understood the material presented by the resource person and would improve their production system by applying GMP and SSOP. By doing so, it is hoped that in the future they will be able to produce quality, continuous, and consistent coffee to maintain its economic value.

#### 3.4. Coffee skin waste into animal feed

Coffee skin or pulp is a fibrous mucilaginous material (by-product) obtained during the processing of coffee cherries by the wet or dry process, respectively. Based on Graph (d), before the training, most of the participants did not understand waste processing. Only 10-20% of the participants knew that coffee skin waste could be used as animal feed and how to process it. 100% of the participants did not know that the fermentation method could improve the quality of animal feed in terms of the nutritional value contained. Training was carried out based on the results of the pre-test. After the training, it was found that the participants understood the material presented by the resource person and were very interested in processing coffee skin waste into animal feed and would immediately give it to their livestock.

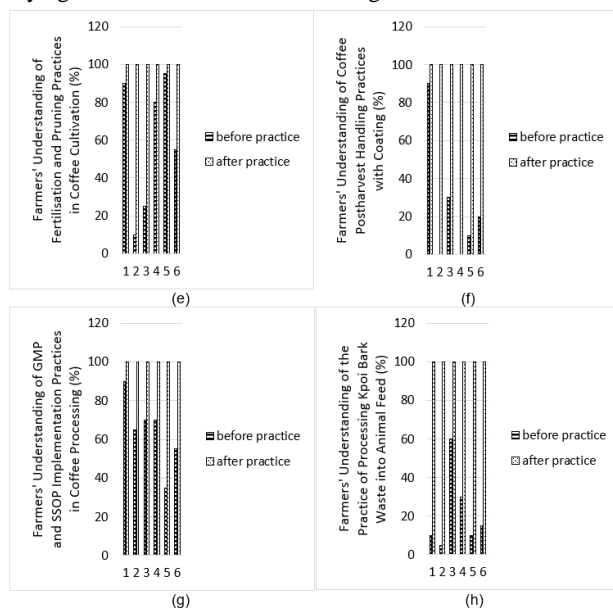


**Fig. 1.** Pre-test and post-test results of the training on (a) Fertilisation and pruning; (b) Postharvest handling of coffee with coating; (c) GMP and SSOP implementation; (d) Processing of waste into animal feed; (d) Processing of waste into animal feed.

#### 3.5. Trial of Fertilisation and pruning, Postharvest handling of coffee with coating, Application of GMP and SSOP, Processing of waste into animal feed, and Processing of waste into animal feed

20 participants attended practices on fertilization and pruning in coffee cultivation. Based on Graph (e), before carrying out the practice, only 20% of participants had processed coffee waste into fertilizer, and only 25% had used coffee waste as fertilizer. Most participants had carried out pruning (95%) but not by the correct pruning technique. Only 55% of participants carried out pruning using the correct technique. The practice is straightforward to understand and will be applied by the participants. The raw materials were easy to find, so participants were enthusiastic about implementing them on their farms. 20 participants attended the practice on coffee postharvest handling with coating. Based on Graph (f), all participants had never made and coated their coffee with coatings before the training. However, 10% of the participants knew the ingredients for making coatings, and 20% knew how to apply coatings to coffee. 30% of the participants knew the benefits of coatings. After the practice, participants will try to apply the coating to their coffee

again. According to the participants, this coating helps them in drying because it can minimize mold growth.



**Fig. 2.** Pre-test and post-test of Trial results of (e) Fertilisation and pruning; (f) Postharvest handling of coffee with coating; (g) Application of GMP and SSOP; (h) Processing of waste into animal feed; (h) Processing of waste into animal feed.

20 participants attended training on coffee processing by applying GMP and SSOP. Based on Graph (g), participants always pay attention to the raw materials' quality. During the production process, participants also pay attention to the cleanliness of the raw materials. However, participants did not paid attention to the cleanliness of the environment and themselves when doing production. Only 70% of participants pay attention to environmental hygiene and only 35% of participants pay attention to their hygiene during production, such as using masks and gloves. After being given an understanding and practiced in the field, participants are willing to improve their sanitation and hygiene and further improve the selection of raw materials used. If participants carry out GMP and SSOP properly, the coffee produced will undoubtedly be of good quality. 20 participants attended training on processing coffee skin waste into animal feed. Based on Graph (h), participants who processed coffee skins into animal feed were only 10% and those who gave it to their livestock were only 5%. Participants in general (30%) carry out the fermentation process but it has not been implemented in animal feed processing. They do not know that the fermentation process can increase the nutritional value of animal feed. In the fermentation process, only 10% of the participants used probiotics and according to 15% of the participants, probiotics were easily available. After the practice of animal feed processing, participants were interested in re-processing and feeding their animals.



**Fig. 3.** Activity Documentation

#### 4. CONCLUSION

Based on the results described, it can be concluded that postharvest management of coffee through the application of coatings with a zero-waste concept is an innovative approach that aims to support the green economy in Wanagiri Village, Sukasada District, Bali. Good postharvest processes, including coating technology, are essential in maintaining coffee quality, particularly in preserving aroma and flavor during storage and transportation. In addition, the application of zero-waste technology in coffee processing has the potential to reduce waste and increase the added value of coffee by-products. This innovation benefits environmental sustainability and improves farmers' welfare through product diversification and income.

#### ACKNOWLEDGMENT

The author thanks the Rector of Warmadewa University in Denpasar, Bali, Indonesia, for the financial support from institutional grants and the AJARCDE editorial team for enabling the author to complete this research. The author hopes that this research can be helpful in the future. Thank you for your cooperation, contribution, and support.

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