Training on Bioconversion of Coffee Pulp Waste into Vegan Leather Raw Material in Dusun Krajan, Tegalharjo, Glenmore, Kabupaten Banyuwangi

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Abstrak

Banyuwangi merupakan sentra perkebunan kopi terbesar di Jawa Timur dengan produksi kopi robusta dan arabika mencapai 10.518 ton per tahun. Limbah perkebunan kopi yang tersedia dalam jumlah melimpah adalah kulit kopi. Kulit kopi dapat dikonversi menjadi kompos/pupuk organik, pakan ternak, serta produk *ecofriendly* seperti nata/membran selulosa. Ketersediaan limbah kulit kopi yang melimpah di Kabupaten Banyuwangi belum ditangani/diolah lebih lanjut agar tidak berdampak terhadap lingkungan. Konversi limbah kulit kopi untuk menghasilkan produk yang bersifat ramah lingkungan (*ecofriendly*) akan berkontribusi terhadap masyarakat sekitar serta dapat meningkatkan nilai tambah limbah tersebut. Dalam rangka mengatasi permasalahan tersebut perlu dilakukan kegiatan yang melibatkan masyarakat setempat dan pemerintah daerah serta pelaku agrowisata melalui penyuluhan dan pelatihan pengolahan limbah kulit kopi/biokonversi menjadi produk *ecofriendly*, sehingga bermanfaat bagi masyarakat di Kabupaten Banyuwangi, khususnya di wilayah Glenmore. Pelatihan peserta diberikan kuisioner untuk penilaian. Berdasarkan hasil analisis kuisioner diketahui bahwa pemahaman peserta di awal kegiatan adalah: 40% peserta sangat kurang paham 13% kurang paham, 20% cukup paham, 13% paham, dan 13% sangat paham terhadap materi Pengolahan limbah kulit kopi. Setelah diberikan pelatihan pemahaman dari peserta meningkat dengan persentase 27% sangat paham, 33% paham, 33% cukup paham, dan masih terdapat peserta yang kurang paham sebanyak 7%. Berdasarkan penilaian peserta 67% merasa manfaat kegiatan ini sangat baik dan harus dilakukan secara berkelanjutan.

Abstract

Banyuwangi is the largest coffee plantation centre in East Java, with robusta and arabica coffee production reaching 10,518 tonnes per year. Coffee plantation waste, which is abundant, is known as coffee pulp. Coffee pulps can be converted into organic compost/fertilizer, animal feed, and eco-friendly products such as cellulose-based nata/membrane. The abundant availability of coffee pulp waste in Banyuwangi Regency has not been correctly handled or processed to prevent environmental impact. Converting coffee pulp waste into eco-friendly products will benefit the surrounding community and increase the added value of the waste. To overcome these problems, it is necessary to engage in activities involving the local community, local government, and agro-tourism actors through counseling and training on processing coffee pulp waste/bioconversion into eco-friendly products, thereby benefiting the community in Banyuwangi Regency, especially in the Glenmore area. Training participants were given a questionnaire for assessment. Based on the results of the questionnaire analysis, it is known that the participants' understanding before the activity is: 40% of participants were very poorly understood, 13% were poorly understood, 20% were quite understood, 13% understood, and 13% were very familiar with the material of processing coffee pulp waste. After receiving training, 27% of participants achieved an excellent understanding, 33% had a moderate understanding, and 33% had a somewhat understanding. Additionally, there were still participants who did not understand as much as 7%. Based on the participants' assessment, 67% felt that the benefits of this activity were excellent and should be carried out on an ongoing basis.

INTRODUCTION

Tegalharjo Village is located in Glenmore Sub-district, Banyuwangi Regency. The topography of the village is in the highlands with an altitude of around 300-400 metres above sea level (Aimah *et al.,* 2019). The village has fertile natural conditions with hills and river flows that support the agricultural sector, especially coffee, cocoa and horticultural plantations. Tegalharjo Village is known for its considerable plantation potential, particularly in the production of coffee, which is the area's leading commodity. These advantages also attract tourists, one of which is the presence of Skyfarm Glenmore, which offers the concept of educational tourism based on sustainable agriculture. Sky Farm Glenmore, provides a variety of organic products produced through environmentally friendly regenerative farming and animal husbandry methods. In addition, Sky Farm Glenmore also offers an educational experience for visitors who want to learn about sustainable lifestyles. Facilities include eco-friendly housing, rainwater management systems, solar power plants, and educational programmes on organic farming and waste management. However, behind this potential, Tegalharjo Village also faces environmental problems, one of which is coffee pulp waste that has not been optimally utilised. This waste is often just thrown away or burned, which has the potential to pollute the environment. Meanwhile, coffee pulp waste contains compounds that can be utilised in various applications, including in the production of environmentally friendly materials. In this Doktor Mengabdi programme, the partner to be developed is Sky Farm. Based on the potential and problems that exist in Tegalharjo Village, an innovative solution is needed that not only optimises agricultural yields but also manages waste sustainably. The utilisation of coffee waste that has not been optimally utilised can be an opportunity for the community to increase economic added value while reducing the impact of environmental pollution. One effort that can be made is to convert coffee pulp waste into vegan leather raw materials through a cellulosic bacterial fermentation process (Absharina *et al.,* 2025). This process involves microorganisms that are able to convert organic compounds in waste into cellulose-based materials with characteristics similar to natural leather. Gluconacetobacter xylinus is one of the most effective acetic acid bacteria for bacterial cellulose production (Aswini *et al.,* 2020). (Jiménez-Sánchez *et al.,* 2024) successfully produced bacterial cellulose using Gluconacetobacter in a medium containing coffee husk infusion. The results of the research indicated the development of a feasible, flexible and eco-friendly material. With this approach, waste that was previously discarded or incinerated can be optimally utilised, producing products that are more environmentally friendly and have broad market potential in sustainable industries. Vegan leather is an alternative to animal leather made from plant-based sources or recycled materials. Bacterial cellulose demonstrates the ability to be produced in sufficient quantities for industrial applications and exhibits high tensile strength, biocompatibility and elasticity, thus making it suitable as a raw material for vegan leather (Absharina *et al.,* 2025). (Kefale *et al.,* 2023) stated that dried bacterial cellulose can produce a flexible, leather-like material with characteristics comparable to animal leather. The material exhibits an average tensile strength of 1.69 MPa and an elastic modulus of approximately 100 MPa, indicating its potential as an eco-friendly leather alternative due to its good flexibility and shape stability. Unlike plastic-based synthetic leather, vegan leather from coffee pulp waste is more sustainable as it uses renewable resources and has a lower carbon footprint. This product can be applied in various industries, such as fashion, automotive, and home furnishings, without compromising environmental sustainability (Ravindra B. Malabadi *et al.,* 2025). The development of vegan leather bioconversion from coffee pulp waste aims to create a circular economy solution in Tegalharjo Village. With this innovation, it is hoped that the community can optimally utilise plantation waste, create new business opportunities, and increase awareness of the importance of sustainable waste management. In addition, the products produced have the potential to be developed into village superior commodities that can attract investment and strengthen the creative economy sector. Therefore, this training programme can provide several alternative solutions to the existing problems while still involving the contribution of the community around Sky Farm. With the active involvement of farmers, business actors, and academics, this programme is expected to create a sustainable innovation ecosystem and provide long-term benefits for Tegalharjo Village, both in terms of economic, social, and environmental aspects.

METHODS

Time and Place

This activity was carried out at Sky Farm Gleenmore Dusun Krajan, Tegalharjo, Glenmore, Banyuwangi Regency. From June 2024 to May 2025. The target participants of the training activities are local communities, environmentalists, representatives from local governments and partners, namely Skyfarm Glenmore.

Partner Issues

Glenmore as an agro-tourism area in Banyuwangi has tourism development that pays attention to the environment with efforts to produce sustainable living, ecofriendly, zero waste and fibre management. These activities were pioneered by Skyfarm Glenmore. Some organic waste such as coconut fibre and banana fronds have been made into pots and paper. Meanwhile, the abundance of coffee pulp waste has not been a concern in zero waste management. Therefore, coffee pulp waste will be converted with the help of microorganisms into cellulose nata/membrane which will be further utilised for other. The methods used in facilitating the problems encountered are as follows :

1. Counselling

   The materials presented in the extension activities include types of agroforestry waste, their potential and utilisation in producing ecofriendly products and processing/bioconversion techniques.

2. Training

   During the training, techniques for processing coffee pulp waste into ecofriendly nata/cellulose membrane products were presented. Furthermore, after 14 days of incubation, harvesting of nata/cellulose membrane results is carried out, then pretreatment and testing of product characteristics (quality of cellulose membranes produced) in the FMIPA UB laboratory, including tensile (stretch) and fibre density. This training activity involves local communities or community groups to actively participate in waste management and product development.

3. Evaluation

   Evaluation of the implementation of the extension and training programme was conducted through questionnaires. While the sustainability of the programme in the field after the activities were carried out was monitored through Instagram social media from Skyfarm Glenmore as well as telephone interviews or zoom meetings at 2-3 months after the training was carried out.

4. Discussion

   Assistance is carried out by conducting direct discussions, involved in solving problems faced by trainees related to the run.

Vegan Leather Raw Material Production

Bacterial cellulose production begins with prepared a coffee pulp extract medium supplemented with other nutritional sources, namely molasses and ZA. The fermentation medium consisted of coffee pulp extract (200 ml), molasses 5% (v/v), and ZA 0.3% (w/v). Coffee pulp extract medium was pasteurised and urea was added during the process. The medium was transferred in sterile bottle and the pH of each medium was adjusted to 4.5-5.5 using NaOH and HCL. Nata de coco starter culture 15% (w/v) was inoculated into the medium aseptically. The jar was covered with brown paper and the sample was incubated for 14 days (Jannah *et al.,* 2018; Machado *et al.,* 2018).

Figure 1. Training on Bioconversion of Coffee Pulp Waste into Vegan Leather Raw Material.

RESULT AND DISCUSSION

Understanding of Coffee pulp Waste Processing Material

The training programme aimed to improve the community's understanding of coffee pulp waste processing. Based on survey data conducted before the training, 53% of respondents had a low level of understanding. This can be seen in Figure 1A, showing that 40% of respondents fell into the very poor category and 13% of respondents in the poor category. Meanwhile, respondents with a sufficient level of understanding related to coffee pulp waste processing reached 20%. The data shows that most of the training participants' do not have adequate knowledge regarding the potential and techniques for optimising coffee husk waste processing. The low level of initial understanding can be caused by several factors, one of which is the limited access of the community to technical information related to coffee pulp waste processing techniques. This has an impact on the low optimisation of the waste utilisation (Murthy et al., 2012). Training participants also said that coffee husk waste is currently more often used as animal feed or simple compost without going through a processing process that can produce products with higher commercial value. Previous research has shown that coffee pulps can be utilised as raw materials in various industries, one of which is as a substrate for fermentation processes (Serna-Jiménez et al., 2022). The training process showed significant results in improving participants' understanding of coffee pulp waste processing. This can be seen in Figure 1B, after the training there were no more respondents who were in the very poor category. Instead, 60% of respondents showed a higher level of understanding than before the training, with 33% of respondents in the excellent category, 27% in the good category, and 33% in the fair category.
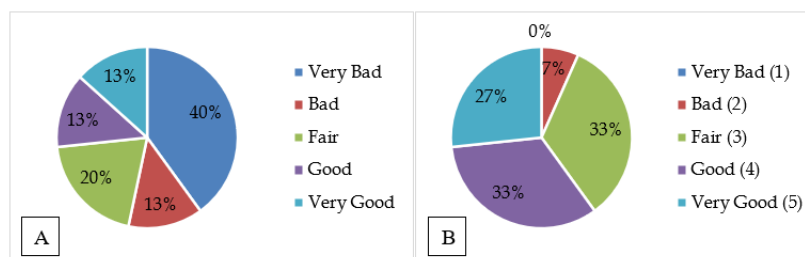

Figure 2. Participants' understanding of coffee pulp waste processing materials (A) before the training (B) after the training.

This increase in understanding indicates that the approach used during the training was effective in providing information to the participants. The approach used was a participatory method, which not only focused on delivering theory but also involved participants directly in the technical demonstration process. Participatory approaches are proven to be able to have a more optimal impact, research (Geissdoerfer et al., 2017) shows that active participation methods can have a significant influence on participant understanding and engagement. In addition, the delivery of information on value-added coffee hull waste is also one of the keys to the success of the training. During the training process, participants were introduced to the potential of coffee pulp waste through the bioconversion process into bacterial cellulose that can be utilised as raw material for vegan leather. The delivery of information related to the added value of coffee pulp waste can attract participants' attention because it shows the economic potential and sustainability value of processing the waste (Mateo et al., 2021).

Participants' Knowledge of Coffee Peel Waste Utilisation

The training programme on making environmentally friendly products from coffee pulp waste is expected to have a significant impact on the community's perspective on the use of such waste. Prior to the training, some communities did not have a deep understanding of the potential of coffee pulp waste. This can be seen in the data shown in Figure 2A, which shows that as many as 47 per cent of respondents did not have adequate knowledge about coffee husk waste processing, while only 13 per cent had very good knowledge about it. After attending two training programmes, the community's knowledge on coffee hull waste processing has increased significantly, as shown in Figure 2B. 43% stated that they have very good knowledge on coffee hull waste processing after attending two training programmes. Meanwhile, another 29 per cent of the community rated their knowledge as good, 21 per cent as fair, and 7 per cent as poor. From these results, it can be concluded that the training programme succeeded in changing the perspective of the community, who initially did not have enough knowledge to process coffee husk waste into an environmentally friendly product, to understand that the waste can be used productively and produce products with economic value.
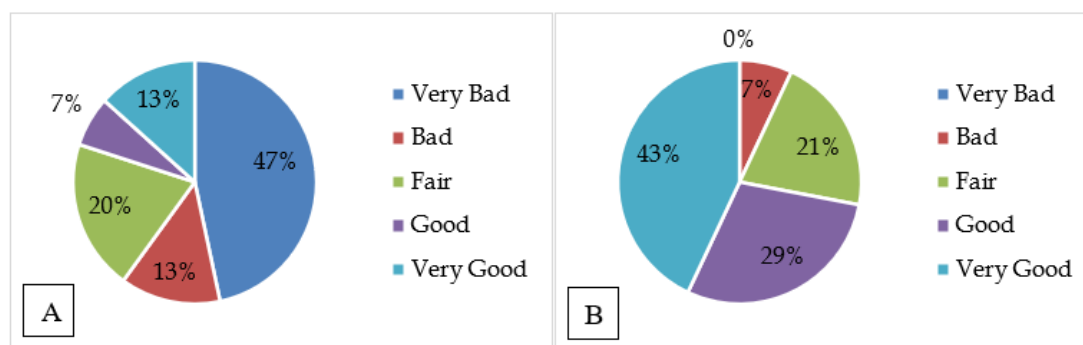

Figure 3. Participants' knowledge of coffee peel waste utilisation (A) before the training (B) after the training. (Wilcoxon test, p < 0.05).

Public knowledge of environmentally friendly products

The training programme aimed to improve the community's understanding of the importance of choosing and using environmentally friendly products. Prior to the training, most participants had very low knowledge of environmentally friendly products. This can be seen in the data shown in Figure 3A, which shows that as many as 33% of respondents did not have adequate knowledge about environmentally friendly products, while only 20% had very good knowledge about them. After participating in the training programme, the community's knowledge of environmentally friendly products has increased significantly, as shown in Figure 3B. 73% of respondents are in the good category and 13% have reached the excellent category. These results show that the training programme succeeded in changing the perspective of the participants, from previously having low knowledge to being able to understand the concept of environmentally friendly products more deeply.
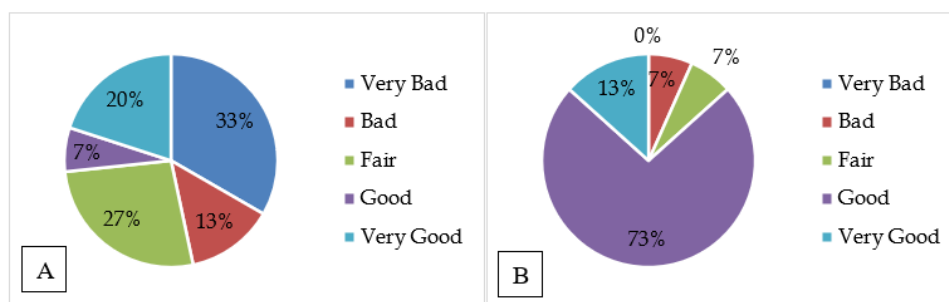
Figure 4. Participants' knowledge of environmentally friendly products (A) before the training (B) after the training.

Participant Skills and Training Benefits

The community's practical skills in processing coffee pulp waste into environmentally friendly products are expected to develop with this training, so that coffee pulp waste can be utilised optimally and sustainably. Previously, most communities had no experience in attending similar training. This can be seen from Figure 4A, which shows that as many as 60% of respondents have never attended training, while the other 40% of respondents have attended similar training.
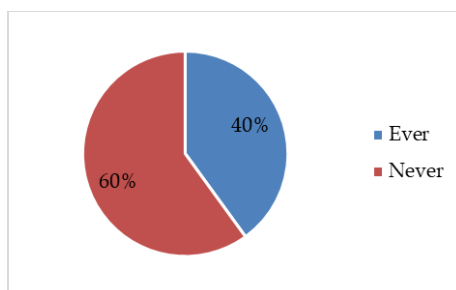

Figure 5. Distribution of people who have participated in such training.

After the first training activity on coffee husk waste processing, 40% of respondents rated their skills as good in practising bioconversion into environmentally friendly products, while only 7% of respondents rated their skills as very poor (Figure 5A). This shows that the training was successful in improving the skills of participants in processing coffee husk waste, who previously had no experience of similar training, to become more skilled in carrying out the bioconversion process in producing environmentally friendly products. After participating in the two-stage training programme, the community's skills in managing coffee pulp waste into environmentally friendly products increased by 30% compared to the one-stage training. This can be seen in Figure 5B , which shows that 43 per cent of respondents rated their skills as excellent after the two-stage training programme. Meanwhile, 29 per cent of respondents rated their skills as good, 14% as adequate and 14% as deficient. The two-stage training programme proved to be effective in improving the community's skills in processing coffee husk waste into environmentally friendly products.
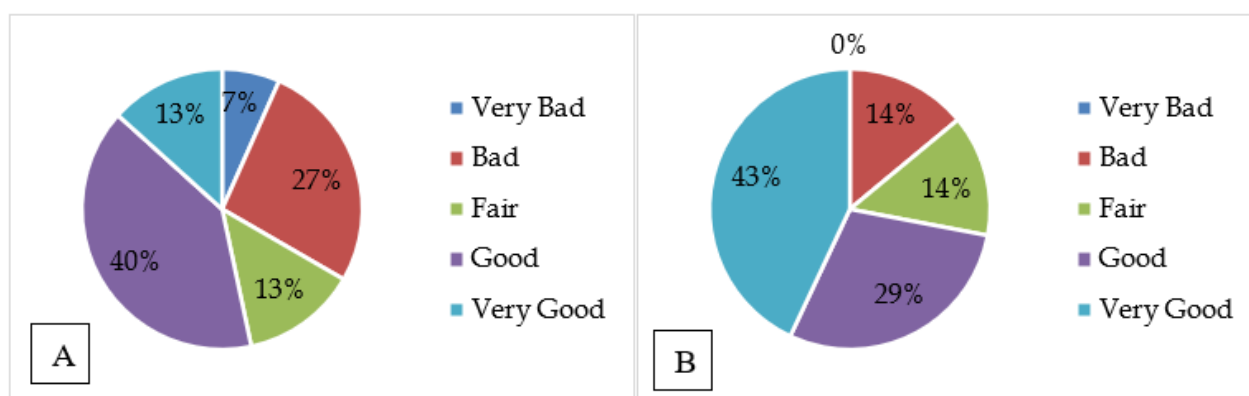

Figure 6. People's skills in practising bioconversion into environmentally friendly products (A) after one training (B) after two stages of training.

The results from Figures 1–5 indicate improvements across all measured aspects after the training, including participants' understanding, knowledge, skills, and ability to produce ecofrienly products. To statistically validate these improvements, a Wilcoxon Signed Rank Test was conducted. The results are presented in Table 1.

Tabel I. Results of pre-test and post-test (Mean ± SD) and Wilcoxon Signed Rank Test.

Aspect	Pre-test	Post-test	Z	p-value
Participants' understanding of coffee pulp waste processing materials	1.27 ± 0.59	3.33 ± 0.62	-2.811	0.005*
Participants' knowledge of coffee peel waste utilisation	1.27 ± 0.59	3.33 ± 0.62	-2.901	0.004*
Participants' knowledge of environmentally friendly products	1.27 ± 0.59	2.67 ± 0.62	-1.706	0.088
Participants' skills in practising bioconversion into environmentally friendly products	1.27 ± 0.59	3.33 ± 0.62	-2.732	0.006*

*Note: $p < 0.05$ indicates statistical significance.

The statistical analysis demonstrated significant improvements in participants' understanding, knowledge, and product outcomes following the training. These findings are consistent with previous studies showing that community-based education and training can effectively enhance awareness and knowledge in waste management and sustainability practices (Murthy et al., 2012; Serna-Jiménez et al., 2022). The increase in understanding and knowledge suggests that the training design, which combined theoretical input with practical exposure, was successful in making the concept of coffee pulp utilization more accessible. Such improvements are critical, as knowledge is often the first step toward enabling communities to independently implement environmentally friendly practices (Mateo et al., 2021). The improvement in product outcomes also supports previous work by Blinová et al., 2017 who highlighted that the development of tangible, value-added products motivates communities to engage more actively in waste utilization initiatives. Producing visible outputs not only reinforces learning but also demonstrates the economic potential of coffee pulp waste, thus increasing the likelihood of long-term adoption. The change in participants' skills was positive but not statistically significant. Similar challenges have been reported in other community-based training contexts, where cognitive gains tend to outpace technical mastery (Yamaner et al., 2021). Skills typically require repeated practice, mentoring, and longer training duration to be fully developed. This indicates that while the programme successfully enhanced participants' knowledge and awareness, follow-up workshops or extended hands-on sessions may be necessary to strengthen practical competencies. The training provided significant benefits to the community, especially in improving knowledge, understanding and skills in processing coffee husk waste. This can be seen in Figure 6A, which shows that 67 per cent of respondents rated the benefits of the training as excellent, 20 per cent as good and 13 per cent as fair. These results show that the training not only provided practical skills to the community, but also had a positive influence on the community's understanding of waste management and the economic potential that can be generated, such as vegan leather. Training plays a role in increasing community knowledge, thus motivating people to create various innovations in waste management, open business opportunities and be able to develop their skills (Yasmaniar et al., 2023). The training programme also had a positive impact on the environment. As shown in Figure 6B, 87% of respondents rated the training programme as very beneficial to the environment and 13% rated it as good. Through this training, coffee pulp waste management is expected to reduce the potential for environmental pollution due to poorly managed waste. Sustainable utilisation of liver resources or reusing scraps generated during the production process into valuable products is one solution to reduce negative impacts on the environment (Serna-Jiménez et al., 2022).
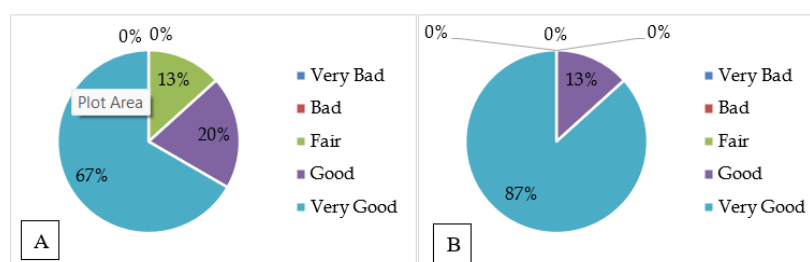
Figure 7. Benefits of the training programme (A) for the community (B) for the environment.

Figure 8. Participants, Students and Lecturers of Doktor Mengabdi Activities
(A) Training Activity I 28 July 2024 (B) Training Activity II 15 August 2024.

CONCLUSION

Based on the results of the training, the community's understanding of the management of coffee pulp waste into vegan leather raw materials has increased so that it is hoped that this will be a solution to the existing coffee fruit peel waste problem.

ACKNOWLEDGEMENTS

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