ASEAN Journal of Community Engagement

Volume 6
Number 2 *December 2022*

Article 5

12-31-2022

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## Recommended Citation

Rizal, Wahyu Anggo; Suryani, Ria; Maryana, Roni; Prasetyo, Dwi Joko; Pratiwi, Diah; Ratnawati, Yuli Ary; Ariani, Dini; and Suwanto, Andri (2022). Coconut Shell Waste Treatment Technology for A Sustainable Waste Utilization: A Case Study of the SMEs in Bohol Village, Indonesia. *ASEAN Journal of Community Engagement*, 6(2), 278-293.
Available at: https://doi.org/10.7454/ajce.v6i2.1182

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ASEAN Journal of Community Engagement
ISSN: 2581-0030 / E-ISSN: 2580-9563
https://scholarhub.ui.ac.id/ajce/
Page. 278–293

# Coconut Shell Waste Treatment Technology for A Sustainable Waste Utilization: A Case Study of the SMEs in Bohol Village, Indonesia

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Received: March 16, 2022, Accepted: November 30, 2022

**Abstract**

This project focused on the introduction of liquid smoke and bio briquette manufacturing technology to small and medium enterprises (SMEs) located in Bohol Village, Gunungkidul, Indonesia through technology transfer, training, and mentoring. These SMEs are engaged in the food business with the main product *jenang ketan*, a traditional food from Gunungkidul, especially in Rongkop District, and very popular among communities around and outside Gunungkidul. The traditional preparation of *jenang ketan* produces several by-products in the form of waste, which is dominated by coconut shell biomass. The project's technology transfer was carried out through the procurement of a series of pyrolysis reactors, distillation reactors, grinder machines, mixer machines, and briquette press machines for SMEs. Afterwards, the training was performed through teaching and practice of SMEs with a focus on the pyrolysis process, bio-briquette process, distillation, application of liquid smoke and bio-briquette, and marketing techniques. The activity was conducted within a period of one-year; continuous mentoring was carried out for the SMEs through consultation and direct field evaluation. The result of the project revealed an increase in the knowledge of SME personnel in the processing of coconut shells waste to produce liquid smoke and bio-briquette and the capability of SMEs to produce their own liquid smoke and briquette.

**Keywords:** technology transfer; coconut shell waste; waste treatment technology; SMEs; Gunungkidul

## 1. Introduction

This paper discusses a community engagement project focused on the introduction of liquid smoke and bio-briquette manufacturing technology to small and medium enterprises (SMEs). The project responds to the issue of by-product from local food production in Bohol Village, Gunungkidul, Indonesia in the form of waste, namely coconut shells. The project does not only focus on introducing the technology to the local community but also provides training and mentoring throughout the process.

## 1.1. Food-based small and medium enterprises (SMEs) in Gunungkidul

Indonesia is an archipelagic country that has abundant natural resources, such as coconut trees. The average production of coconuts in Indonesia is 15.5 billion grains/year, which is equivalent to 3.02 million tons of copra, 3.75 million tons of coconut water, 0.75 million tons of coconut shells, 1.8 million tons of fiber from coconut fiber, and 3.3 million tons of coconut coir dust (Mahmud & Yulius, 2015). Rongkop is one of the sub-districts in Gunungkidul Regency, Daerah Istimewa Yogyakarta, which is located on the east side and directly adjacent to the Province of Central Java (Figure 1). As one of the typical traditional foods of Gunungkidul which is mostly produced in Rongkop sub-district, *jenang ketan* is made from local raw materials in the form of glutinous rice, paddy rice, coconut, and brown sugar.

With the rise and expansion of SMEs in Indonesia, community engagement has become a vital indicator for key actors and stakeholders. This article shows the constructive relationship between traditional food enterprise and government institutions, especially research centers, to make community engagement not only desirable but necessary as it is likely to lead to equitable and sustainable public decisions and application of science and technology for local communities. In Rongkop sub-district, several groups of SMEs produce *jenang ketan*. One of them is located in Bohol Village, with 10 members dominated by housewives.

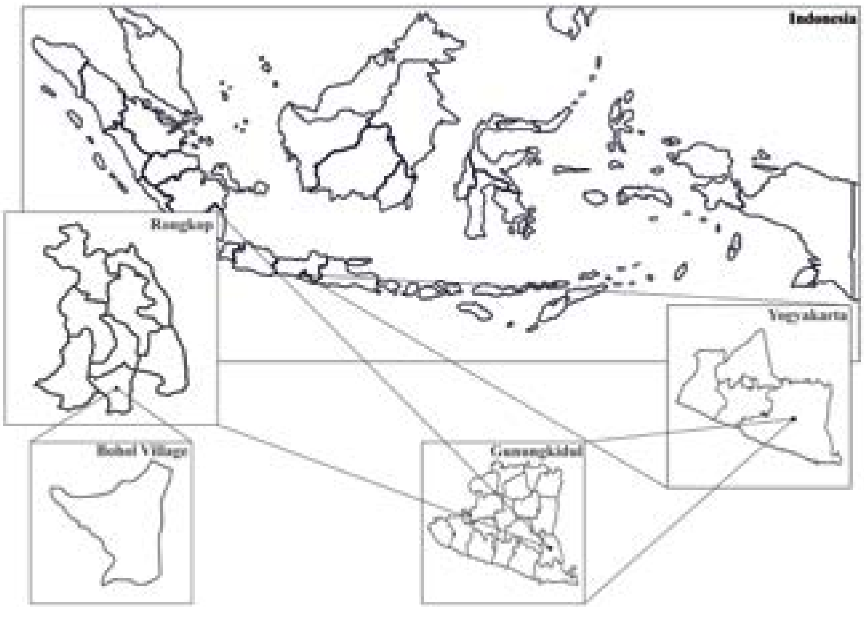


Figure 1. Map of Bohol Village, Rongkop District, Gunungkidul Regency, Special Region of Yogyakarta

The process of making *jenang ketan* produces several by-products in the form of coconut shell waste. Coconut shell is a part of the coconut fruit that biologically functions as a protective core and is located inside the coconut husk (Rasi & Seda, 2014). Coconut shells are included in the hard-wood group with thickness ranging from 2 mm to 6 mm and moisture content of 6%–9% based on dry weight (Aziz et al., 2011). Coconut shell waste from *jenang ketan* production can be further processed and thus has a high economic value. Potentially, coconut shells can be used as raw materials for the production of liquid smoke, bio-briquettes, and handicrafts. In the case of Bohol Village, the conversion process of coconut shell waste into liquid smoke and bio-briquettes would be the easiest method to introduce such waste utilization to the community due to its simple application techniques and relatively smooth implementation and maintenance. The transfer of coconut shell waste processing technology can arguably have a positive impact on the Bohol Village community, especially to the SMEs that produce *jenang ketan*.

The people of Bohol Village generally use coconut shell waste from *jenang ketan* production directly as fuel for clay stoves without further processing. Our project aims to introduce the Bohol Village people a technology that further processes the coconut shell waste that has higher functional and economic value, such as liquid smoke and bio-briquette. In 2021, a total of 4,064 micro-enterprises in Gunungkidul were proposed to obtain micro business productive assistance. Therefore, technology introduction to these communities will significantly impact sustainable businesses (Najib, 2021). Community project in this article connects the concept of welfare (income of the community) with the traditional food SMEs by transforming the waste into liquid smoke and bio-briquette technology, producing higher-economic-value products.

### 1.2. Technology process

However, there is a limitation of crude or full-strength liquid smoke is the high content of hazardous compounds, which make it unsuitable for certain purposes, such as antimicrobial agents. However, crude or full-strength liquid smoke can be purified for various applications through several processes, including fractionation and distillation (Montazeri et al., 2013). The contents of phenol derivatives, carbonyl-containing compounds, and organic acids is adjusted to achieve the desired aroma and color characteristics of the final product. As a result, the purified liquid smoke will experience changes in acidity, color, and chemical composition compared with crude or full-strength oil.

On the other hand, the utilization of bio-briquette as a fuel can replace the use of firewood and can be used to conserve fuel oil, especially kerosene which is currently limited. In addition, the price of bio-briquette is relatively cheap and affordable to the public. Some advantages of bio-briquette utilization include its low cost, odorless, high calorific value, non-toxic, environmental friendliness, and slow transformation to ash (Faisol et al., 2014). Charcoal from coconut shell has a calorific value of about 5,655 calories/gram (Fariadhie, 2009). Thus, the utilization of briquette from coconut shells and charcoal as fuel can provide some advantages, such as absence of smoke production and easy cleaning and packing.

### 1.3. Technology transfer

Bozeman et al. (2000) stated technology transfer as a movement of knowledge, comprising technical knowledge and a shift from one organization setting to another. Based on this definition, technology transfer refers to the process of transferring innovations developed from institutional inventions to communities, where value is created and impact is achieved. The transfer of knowledge and inventions to the society has at least two goals, namely the advancement in the economic field and the social benefit for the community. On the other hand, the academic institutions can also play role in such technology transfer to benefit the society (Enders & Westerheijden, 2011; Mars & Burd, 2013). Economic success is relatively easy to measure (e.g., increased sales), but social benefits are not. The concept of technology transfer is usually defined by licensing research results to industrial partners or establishment of spin-out companies for commercialization, however, in this case, it would be more important to make valuable contributions to society.

For a successful technology transfer, the transferred technology must be conveyed to the people who need it according to local conditions. Considerable efforts may be required to ensure that technology transfer is beneficial and appropriate for the targeted communities (Piachaud, 1979). As Romer (1994) suggests through his endogenous growth theory that technology is an endogenous variable which should be supported by the human capital as a crucial aspect in technology transfer. Romer (1994) mentioned three basic elements in the theory of endogenous growth: 1) the process of knowledge accumulation achieves technological change; 2) the abundance of knowledge enables the creation of new ideas; 3) the existence of production factors in the form of knowledge will trigger the growth of production of consumer goods. Meanwhile, according to Schumpeter (1949), the main factor that causes economic development is the innovation process of innovators or entrepreneurs. Innovation concerns the quantitative improvement of the economic system originating from the creativity of the entrepreneurs who have the following three influences: 1) the emergence of new technologies; 2) increased business profits that are used as business capital; 3) encouragement of business actors to imitate a new technology or product being released.

New technologies developed from within a community or society and those transferred from the outside are still needed by any community or nation that wants to improve the welfare of a large number of individuals (Billups & Juliá, 2019). Although technology can be used for the benefit of mankind, attention must be focused on the possibility that it can also harm humans. Inappropriate creation and transfer of technology are described as an occasionally subtle and overt form of institutional violence to the society. Compared with previous research, this study bridges the technology transfer that provides a suitable and applicable apparatus for SMEs. It introduced and installed a series of pyrolysis reactors, distillation reactors, grinder machines, mixer machines, and briquette press machines for SMEs.

The novelty of this research is the reactor design suitable for SMEs, including the size dimensions and fuels. Regarding fuel, liquefied petroleum gas (LPG) was selected because of electricity supply issues in the rural area. In this case, the SMEs in Bohol village currently lacks the knowledge and ability to manage the waste generated from the production of *jenang ketan*, that is, coconut shells. The people of Bohol Village generally use coconut shell waste from making *jenang ketan* directly as fuel for cooking with traditional hearth without further processing. Therefore, coconut shell waste is not utilized for a specific purpose.

## 2. Methods

This project consists of three parts, the first one is the observation of the SMEs activity, the second one demonstration on the technology, and the third is technology assistance.

### 2.1. Observation

This research used observation and descriptive qualitative research methods, which were combined to explain this study overall. This part was carried out in October 2018, starting with observation activities. The target of technology introduction project is Arimbi SME's group in Dusun Bohol, RT 16 RW 06 Bohol Village, Rongkop, Gunungkidul Regency, Special Region of Yogyakarta. The Arimbi is engaged in the business of making *jenang ketan* and consists of 10 members dominated by housewives. Observations were conducted before procurement, socialization, and training to determine the characteristics of the project target, including the presence or absence of prior knowledge related to the manufacture of liquid smoke and briquette, production capacity for *jenang ketan*, coconut shell waste generated every month, and the extent of the utilization and processing of coconut shell waste thus far. The production machine capacity was determined by field observations and direct interviews with SME personnel as a consideration for making machine designs.

Interviews were carried out to determine the success of the activity before and after the commencement of the project. The interviews applied a qualitative approach to obtain primary information from the community regarding their knowledge of liquid smoke and bio-briquette, awareness of coconut shell waste utilization, knowledge of the pyrolysis process and bio-briquette making, and desire of the community to process coconut shell waste into liquid smoke and bio-briquette.

### 2.2. Coconut shell waste conversion production process

During pyrolysis, the components of hemicellulose, cellulose, and lignin are decomposed into three groups of compounds, namely, volatile and condensable compounds, non-condensable gases, and solids, such as charcoal and ash. Figure 2 shows a schematic of the conversion of coconut shell waste as an ingredient for making liquid smoke and bio-briquettes through the pyrolysis process.

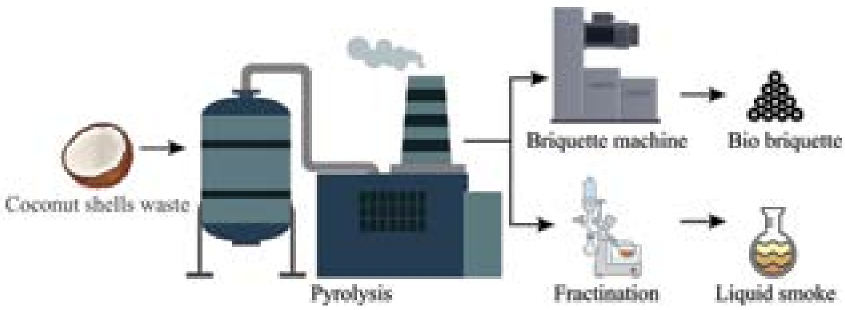


Figure 2. Schematic of pyrolysis using coconut shell waste as a material to produce liquid smoke and bio-briquette

The production process followed a previously described method (Rizal et al., 2020) starting from drying the raw material and continued by the analysis of biomass composition using Chesson's Method to determine the lignocellulosic composition of the raw material. The information on the lignocellulosic composition of the raw material can be used to determine the dominant chemical compound to be obtained in the liquid smoke product. Then, the raw material was reduced by ±1–5 cm in size using a grinder and packaged with a weight adjusted to the reactor capacity of 10 kg. Pyrolysis was carried out at 500°C for 8 hours. The resulting charcoal from the pyrolysis process was pressed with a machine at a charcoal-to-starch ratio of 1:25, whereas the ratio of water to binder (starch) was 1:8.

### 2.3. Introduction of technology

Technology introduction was carried out through several stages, namely a) procurement of instruments for processing coconut shell waste into liquid smoke and bio-briquette based on the capacity and capability of SME; b) instrument performance test at the SME site; and c) training and workshops to improve the knowledge and skills of SMEs related to processing coconut waste into liquid smoke and bio-briquette. Figure 3 shows the overall process diagram carried out at the introduction of coconut shell waste processing at the Arimbi SME.

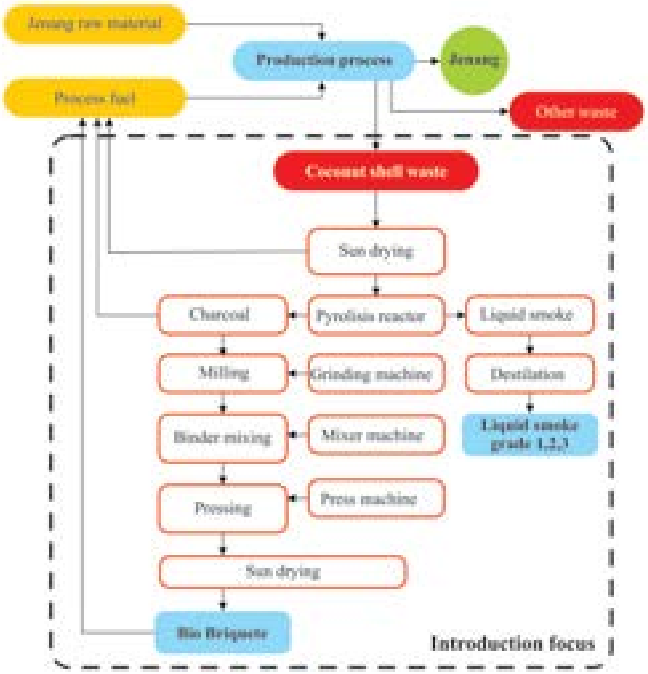


Figure 3. Process diagram of coconut shell waste processing into liquid smoke and bio-briquette in the Arimbi SME, Bohol Village

### 2.4. Evaluation and monitoring

The evaluation was carried out after the introduction of coconut shell waste treatment technology. It focused on the five aspects, which consist of improvement in the knowledge of SME personnel on the technique of processing coconut shells into liquid smoke and bio- briquette, as well as improvement in the skills of SME personnel in processing coconut shell waste into liquid smoke and bio-briquette. In addition, the evaluation process also considers the possibilities of improvement in utilization of liquid smoke and bio-briquette products obtained from the introduced processing techniques, independence of SMEs in processing coconut shell waste without direct assistance from the team and overall monitoring during and after program implementation.

## 3. Results and Discussion

### 3.1. Observation results

Five people were interviewed as representatives of Arimbi SME's group and villagers of Bohol Village. Field observations and direct interviews revealed that the production capacity of *jenang ketan* requires 1,000 coconuts per month and obtains a by-product in form of coconut shell waste which is used in cooking process directly as fuel and, afterwards, sold to collectors for IDR 1,000/kg. Field observations showed that the pyrolysis reactor needed 40 kgs for each process to accommodate the production capacity of SMEs. This knowledge however is not yet known by the Bohol villagers, including Arimbi SME as entrepreneurs of *jenang ketan*. They have a lack of basic knowledge related to processing liquid smoke and have minimal knowledge about bio -briquette and thus the technology transfer becomes crucial.

## 3.2. Production process results

Table 1 presents the results of the lignocellulosic component characterization from coconut shell waste. Cellulose and lignin accounted for the highest percentage, indicating that the dominant groups of compounds in liquid smoke were phenol and carbonyl. The table compares the result from field and similar researches.

Table 1. Comparison of coconut shells chemical composition

| Component | (Husseinsyah & Zakaria, 2011) | (Budi et al., 2012) | (Hasanah et al., 2012) | (Sa'diyah et al., 2018) | Analytical result |
|---|---|---|---|---|---|
| Hemicellulose | ¬ | 21% | 32% | ¬ | 20.35% |
| Cellulose | 26.6% | 34% | 14% | 27.31% | 36.13% |
| Lignin | 29.4% | 27% | 46% | 33.30% | 32.32% |

Liquid smoke can effectively inhibit various types of spoilage and pathogenic microorganisms. Phenolic compounds are responsible for the smoke flavor in liquid smoke and have antibacterial and antioxidant properties (Soldera et al., 2008). Phenol is one of the germ-killing components in liquid smoke, and acetic acid increases the microbial deactivation activity carried out by phenol. Liquid smoke has an inhibitory effect on the following: *Escherichia coli*, *Salmonella choleraesuis* (Soares et al., 2016; Suryani et al., 2020), *Staphylococcus aureus*, *Listeria monocytogenes* (Milly et al., 2006, de Souza et al., 2018), *Salmonella enteritidis* (van Loo et al., 2012), *Salmonella typhimurium*, *Salmonella muenster*, *Salmonella senftenberg*, *Pseudomonas putida*, *Pseudomonas aeruginosa*, *Lactobacillus plantarum*, *Listeria innocua*, *Aeromonas hydrophila*, and *Yersinia enterocolitica* (de Souza et al., 2018).

## 3.3. Results of technology transfer

### a. Procurement of instruments for processing coconut shell waste into liquid smoke and bio-briquette in accordance with the observation results

The team created a master design of pyrolysis reactor instruments based on the observations made through direct interviews with SME personnel and field observations. The capacity of every instrument was adjusted to the amount of coconut shell waste produced by *jenang ketan* production. The production of liquid smoke and bio-briquette requires several tools, including a series of pyrolysis reactor, grinder machines, distillation reactor, mixer machine, and briquette press machine.

Figure 4 illustrates the instruments procured for producing liquid smoke and bio-briquette production in the Bohol Village. The pyrolysis reactor was designed as a slow-pyrolysis type with a capacity of 40 kgs for each process with high pressure LPG fuel and equipped with a temperature controller and condenser. The reactor was made of stainless-steel material. The pyrolysis reactor circuit had a cyclone to precipitate the tar resulting from the smoldering process to prevent tar condensation together with the smoke liquid. The pyrolysis reactor was smoldered in minimal oxygen conditions to produce smoke, which was then cooled by the condenser to produce liquid smoke. Coconut shells were turned into charcoal after the smoldering process. A grinder with a capacity of 30–40 kgs/h and driven by an electric motor was used to reduce the size of coconut shells, followed by the drying process to accelerate the heat transfer process during pyrolysis. In addition, the grinder machine can be used to reduce the size of pyrolysis charcoal before preparing the dough for bio-briquette. The distillation reactor was designed with a capacity of 30 L low-pressure LPG fuel and equipped with a stainless-steel condenser to purify liquid smoke into several grades. The mixer machine with a capacity of 5 kgs/process was driven by an electric motor and used to homogenize the briquette dough. The press machine had a capacity of 10 kgs/process, with power transmission using threads and a manual drive to mold bio-briquettes. The bio-briquettes were formed in the shape of tubes with a size of 3.5 cm x 8.5 cm, with a total of 16 pieces produced in every batch.

(a) (b) (c) (d) (e)

Figure 4. The instruments procured for coconut shell waste processing into liquid smoke and bio-briquette in Bohol Village: (a) pyrolysis reactor, (b) grinder machine distillation, (c) reactor, (d) mixer machine; (e) briquette press machine

**b. Instrument performance test at the SME site**

Performance tests were conducted to determine the level of readiness of the instrument. Several obstacles were found. Notably, the grinding and mixer machine use electric motors and require 1,100 W of electric power and cannot be operated on the electrical installation network in Bohol Village. Thus, a design concept for tools that use electric power above the average electric power at the installation site was developed.

**c. Training and workshops to improve the knowledge and skills of SMEs related to processing coconut waste into liquid smoke and bio-briquette**

Direct training can provide an opportunity to understand the learning process comprehensively and completely and is one way to develop human resources (Awali et al., 2018). The training and workshop were held on December 12–13, 2018 at Research Division of Natural Product Technology, Indonesian Institute of Sciences (BPTBA LIPI), Gunungkidul, Special Region of Yogyakarta with the title, 'Utilization of Coconut Shells from *Jenang* Production Waste as Liquid Smoke and Bio-briquette.' The participants were all members of the Arimbi SME and representative officials of Bohol Village. The trainers as facilitators were a research team from BPTBA LIPI and academic members of Faculty of Engineering, Universitas Muhammadiyah Yogyakarta. Figure 5 shows the documentation of the training activities, workshops, and product examples.


Figure 5. Documentation of training and workshop activities for processing coconut shell waste into liquid smoke and bio-briquette: (a) preparation of drying coconut shell waste, (b) practicing pyrolysis of dried coconut shell waste, (c) liquid smoke obtained from left to right (crude and after distillation), (d) charcoal grinding process, (e) theoretical class, and (f) participants in the training and workshop

On the first day of training, the participants learned about the theory of pyrolysis, bio-briquette process, distillation technique, the potential application of liquid smoke and bio-briquette, and product marketing techniques. The activities on the second day involved the practice of making liquid smoke and bio-briquette and evaluating the training results. The participants are accompanied by the team to practice the production process directly, starting from the preparation of coconut shell waste, using the pyrolysis reactor, making bio-briquette dough, and molding it into ready-to-use briquette pellets.

The steps started by drying the coconut shells under the sun until they reached a moisture content of 10%–20%. The dried coconut shells were then placed in the grinder machine to reduce their size to minimize the empty use of space in the pyrolysis reactor. The pyrolysis reactor was closed tightly and the pyrolysis process was carried out for 8 hours at a temperature of approximately 500°Celsius. A thick black liquid known as tar, which prevented the viscous liquid from mixing with the liquid smoke obtained, was collected from the middle of the pipe. Bottles containing frozen water were used to maintain condenser water in cold temperature conditions.

The charcoal obtained from coconut shell pyrolysis was used to make bio-briquette. Good-quality charcoal is indicated by even black color, absence of impurities, and presence of a luminous tip. The size of the charcoal was then reduced using a grinder machine. Bio-briquette is a dough made from a mixture of pyrolysis charcoal with starch as a binder agent, with a coconut shell-to-starch ratio of 1:25 and water-to-starch ratio of 1:8. Good-quality briquette was determined by the ratio or composition of materials and the right adhesive. The dough was placed in a press machine and molded to form bio-briquette pellets. The liquid smoke obtained from pyrolysis was transferred to a distillation reactor to produce the liquid smoke fraction. Distillation was carried out at various temperature (100°C, 100°C–125°C, 125°C–150°C, and 150°C–200°C). The results of liquid smoke distillation at each temperature range can be used based on the physicochemical characteristics contained therein. As a result, the distilled liquid smoke could be divided into several grades—grade 1 for food applications, grade 2 for preservation of raw food ingredients in the form of meat and fish, and grade 3 for preservation of rubber and elimination of fungi and pathogenic bacteria in ponds.

### 3.4. Evaluation, monitoring, and technology assistance

Monitoring during the program was carried out directly through discussions, and monitoring after was implemented through indirect discussions. Technological assistance can be interpreted as an effort to assist, direct, and support activities through problem formulation, activity planning, implementation, and evaluation of business development (Sihombing, 2018) until the participants can carry out the process independently. If the community groups can make their own decisions and choices for their business units and are not bound by other people, the process then can be considered as independent. Another form of independence is determining the choice of raw material procurement, processing of raw materials, and packaging and labeling products to manage buying and selling transactions (Sunarsih, 2020). Continuous technology assistance was carried out for community groups, both through consultation, product development, and direct field evaluations. Through the concept of sustainable assistance, the community in Bohol Village, especially the SMEs, will continually receive technical and non-technical guidance and assistance related to the processing technology for making liquid smoke and bio-briquettes.

### 3.5. Discussion

The interview results showed that the technology introduction successfully provided initial information regarding the transformation of coconut shell waste and made people aware about the utilization of coconut shell waste (Table 2).

Table 2. The comparison of the condition before and after the introduction of technology based on the interview with Bohol villagers

| No | Aspect | Before | After |
|---|---|---|---|
| 1 | Knowledge about liquid smoke | 0% know | 100% know |
| 2 | Knowledge about bio-briquette | 20% know | 100% know |
| 3 | Awareness about coconut shells waste utilization | 0% aware | 100% aware |
| 4 | Knowledge about pyrolysis process | 20% know | 100% know |
| 5 | Knowledge about bio-briquette making | 20% know | 100% know |
| 6 | Desire to process coconut shell waste into liquid smoke and bio-briquettes | 0% want | 100% want |

*Data from interviews and direct observation of participants and village Apparatus, before and after program activities

From the table above, it can be seen that there is a technology transfer in terms of knowledge movement in the community. The technology introduction successfully persuaded the public to attempt producing liquid smoke and bio-briquette by themselves. Before socialization, the community knew very little about liquid smoke, and a limited number of people were aware that coconut shell waste can be processed into liquid smoke. After the technology introduction, the increase in the interviewee's knowledge was around 80%–100%. This result is similar to the knowledge about pyrolysis and bio-briquette making, which showed an increase of approximately 80%. The desire to process coconut shell waste into liquid smoke and bio-briquette increased in a value close to 100% after the activities.

In terms of improving skills in processing coconut shell waste into liquid smoke and bio-briquette, SME personnel and Bohol villagers have been taught and practiced directly how to process coconut shell waste, from preparation or drying, operating a pyrolysis reactor, using a grinder machine, operating a distillation reactor to the manufacturing of bio-briquette. An increase of knowledge of SME personnel and residents of Bohol Village has been observed regarding the technique of processing coconut shells into liquid smoke and bio-briquette after training and introduction workshops. After the activity, the villagers learned about further benefits of coconut shell waste.

Regarding the improved utilization of liquid smoke and bio-briquette products obtained from the introduced processing techniques, the SME personnel and Bohol villagers succeeded in increasing the use value of their coconut shell waste. Previously, the coconut shell waste was only used as a direct fuel for clay stoves and sold cheaply in bulk. After the training, the coconut can now be transformed into bio-briquette fuel, which is more environmentally friendly, does not cause smoke and liquid smoke, and be used for various needs. The SMEs and Bohol villagers can process independently coconut shells waste without direct assistance from the facilitator team after the training and workshop activities. The SME personnel and Bohol villagers operated the tools independently and their difficulties were discussed with the research team. If there is any problem, most of the difficulties encountered were related to technical problems.

As an illustration of the economic value obtained from the application of the introduced technology, initially, the coconut shells waste obtained from the processing of *jenang ketan* was mostly used as cooking fuel and sold to collectors at a price of IDR 1,000/kg. The pyrolysis technology will yield two products: liquid smoke and bio-briquette with the domestic price of bio-briquettes starting at IDR 2,000/kg–IDR 2,500/kg and the export prices in the range of IDR 6,000/kg–IDR 8,000/kg (Mahmud & Yulius, 2015). Meanwhile, the selling value of liquid smoke concentrate is offered at IDR 200,000/L for food-grade types (Swastawati, 2011), and the agricultural grade type is priced at IDR 16,500/L. Bohol villagers use liquid smoke for agricultural applications and bio-briquettes as stove fuel, which has several advantages, including flammability but slow exhaustion, smokeless, and environmental friendliness.

## 4. Conclusion

From the project, it can be learned that the process of technology transfer requires not only the development of suitable equipment design but also training and mentoring activities. In the case of Bohol Village, the technology transfer needs more detailed stages. The processing technology of coconut shell waste obtained from the production of *jenang ketan* in Bohol Village was introduced through several stages, including observation, procurement of instruments, and training and workshops in the context of technology transfer. As a result, the introduction of technology for processing coconut shell waste into liquid smoke and bio-briquette to the residents of Bohol Village increased the knowledge and skills of Bohol villagers in coconut shell waste processing. In terms of strengthening the community capacity, this activity increased their awareness of coconut shell waste utilization and knowledge on the pyrolysis process and bio-briquette making and raised the public's desire to process coconut shell waste into liquid smoke and bio-briquettes.

In addition to introducing new technologies for the utilization of coconut shell biomass waste to SMEs, this activity program can increase the knowledge and skills of the community in the application of coconut shell waste processing technology. The results of this activity not only affect the SME members who are involved but also the surrounding community who contribute to the procurement of raw materials for coconut shell waste. From the results of daily household activities, the beneficiaries are not only limited to SME members but also the surrounding community.

The drawback of this program is that the production of liquid smoke and bio-briquette are still not optimal. This is due to the lack of strength in the manual labor, which in this case, most of the SMEs members are housewives. Strength is required in the manual labor for i.e., pressing of briquettes and pyrolysis processes. In addition, the drawback is also due to the incompatible power supply. The low electric supply of an average household at the Bohol Village prevents the use of several tools that utilize electric motors above 1,100 Watts. Thus, the introduced technology needs to be developed further for production tools that can be used by women and can operate with low power supply. Assistance activities through direct and indirect communication will be continuously carried out to overcome the technical obstacles encountered in the processing of coconut shell waste. As local food production has a specific material cycle and by-products, the lesson learned from this project opens up opportunities in similar community projects based on the technology transfer along with the required program and activities

**Acknowledgment**
We thank all the laboratory assistants and engineering technicians of BPTBA LIPI for supporting this activity. Likewise, the authors are grateful for the critical comments and suggestions from the editor and reviewers of the ASEAN Journal of Community Engagement.

**References**

Awali, J., Ismail, I., Aryatama, O., Triana, Y., & Asih, W. (2018). Pelatihan daur ulang logam (alumunium) bagi masyarakat Karang Joang. *Jurnal Pengabdian Kepada Masyarakat*, *4*(1), 1–10. https://doi.org/10.22146/jpkm.30313

Aziz, T., Indraman, M. F., & Alawiyah, U. (2011). Pemanfaatan tempurung kelapa dan tempurung sawit untuk pembuatan asap cair sebagai penghilang bau pada lateks dengan metode pirolisis. *Teknik Kimia*, *17*(8), 41–48.

Billups, J. O., & Juliá, M. C. (2019). Technology transfer and integrated social development: International issues and possibilities for social work. *The Journal of Sociology & Social Welfare*, *23*(1), 236–247. https://doi.org/10.4324/9780429438776-14

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy*, *29*(4–5), 627–655. https://doi.org/10.1016/S0048-7333(99)00093-1

Budi, E., Nasbey, H., Budi, S., Handoko, E., Suharmanto, P., Sinansari, R., & Sunaryo, S. (2012). Kajian pembentukan karbon aktif berbahan arang tempurung kelapa. *Prosiding Seminar Nasional Fisika*, *1*(1), 62–66.

de Souza, J. L. S., da Guimarães, V. B. da S., Campos, A. D., & Lund, R. G. (2018). Antimicrobial potential of pyroligneous extracts—a systematic review and technological prospecting. *Brazilian Journal of Microbiology*, *49* (1), 128–139. https://doi.org/10.1016/j.bjm.2018.07.001

Enders, J., Boer, H. F., & Westerheijden, D. F. (Eds.). (2011). *Reform of Higher Education in Europe*. SensePublishers. https://doi.org/10.1007/978-94- 6091-555-0

Faisol, A., Anggun, T., & Nurzeni, F. (2014). Pembuatan briket dari campuran limbah plastik LDPE, tempurung kelapa dan cangkang sawit. *Teknik Kimia*, *20*(2), 45–54.

Fariadhie, J. (2009). Perbandingan briket tempurung kelapa dengan ampas tebu, jerami dan batu bara. *Tatal Jurnal Teknik*, *5*(1), 1–8.

Hasanah, U., Setiaji, B., Triyono, T., & Anwar, C. (2012). The chemical composition and physical properties of the light and heavy tar resulted from coconut shell pyrolysis. *The Journal of Pure and Applied Chemistry Research*, *1*(1), 26–32. https://doi.org/10.21776/ub.jpacr.2012.001.01.102

Husseinsyah, S., & Mostapha. M. (2011). The effect of filler content on properties of coconut shell filled polyester composites. *Malaysian Polymer Journal*, *6*(1), 87–97.

Lingbeck, J. M., Cordero, P., O'Bryan, C. A., Johnson, M. G., Ricke, S. C., & Crandall, P. G. (2014). Functionality of liquid smoke as an all-natural antimicrobial in food preservation. *Meat Science*, *97*(2), 197–206. https://doi.org/10.1016/j.meatsci.2014.02.003

Mahmud, Z., & Yulius, F. (2015). Prospek pengolahan hasil samping buah kelapa. *Perspektif: Review Penelitian Tanaman Industri*, *4*(2), 55–63. http://dx.doi.org/10.21082/p.v4n2.2005.%25p

Mars, M. M., Burd, R. (2013). Impact over revenue: Toward a social entrepreneurship model for university technology transfer. *Journal of Entrepreneurship &*

*Organization Management*, *2*(1), 1–7. https://doi.org/10.4172/2169-026x.1000104
Milly, P. J., Toledo, R. T., & Ramakrishnan, S. (2006). Determination of minimum inhibitory concentrations of liquid smoke fractions. *Journal of Food Science*, *70*(1), 12–17.
Montazeri, N., Oliveira, A. C. M., Himelbloom, B. H., Leigh, M. B., & Crapo, C. A. (2013). Chemical characterization of commercial liquid smoke products. *Food Science & Nutrition*, *1*(1), 102–115. https://doi.org/10.1002/fsn3.9
Najib, A. (2021, July 21). *4,064 usaha mikro di Gunungkidul diusulkan peroleh bantuan produktif.* iNewsYogya.id. https://yogya.inews.id/berita/4064-usaha-mikro-di-gunungkidul-diusulkan-peroleh-bantuan-produktif
Piachaud, D. (1979). The diffusion of medical techniques to less developed countries. *International Journal of Health Services*, *9*(4), 629–643. https://doi.org/10.2190/QVK8- J638-W8V7-6F9J
Rasi, A. J. L., Seda, Y. P., & Anggraini, S. P. A. (2014). Potensi teknologi asap cair tempurung kelapa terhadap keamanan pangan. *eUREKA: Jurnal Penelitian Teknik Sipil dan Teknik Kimia*, *1*(1), 1–10.
Rizal, W. A., Nisa', K., Maryana, R., Prasetyo, D. J., Pratiwi D., Jatmiko, T. H., Ariani, D., & Suwanto, A. (2020). Chemical composition of liquid smoke from coconut shell waste produced by SME in Rongkop Gunungkidul. *IOP Conference Series: Earth and Environmental Science*, *462 012057.* IOP Publishing. https://doi.org/10.1088/1755-1315/462/1/012057
Romer, P. M. (1994). The origins of endogenous growth. *The Journal of Economic Perspectives*, *8*(1), 3–22.
Sa'diyah, K., Rohman, F., Harsanti, W., Nugraha, I., & Febrianto, N. A. (2018). Pyrolysis of coconut coir and shell as alternative energy source. *Jurnal Bahan Alam Terbarukan*, *7*(2), 115–120. https://doi.org/10.15294/jbat.v7i2.11393
Schumpeter, J. A. (1949). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. Harvard University Press.
Sihombing, N. L. N. (2018). Model pendampingan UKM di kota Tangerang Selatan. *Prosiding Seminar Nasional Hasil Pengabdian Kepada Masyarakat*, *1*(1), 84–90.
Soares, J. M., da Silva, P. F., Puton, B. M. S., Brustolin, A. P., Cansian, R. L., Dallago, R. M., & Valduga, E. (2016). Antimicrobial and antioxidant activity of liquid smoke and its potential application to bacon. *Innovative Food Science and Emerging Technologies*, *38*(A), 189–197. https://doi.org/10.1016/j.ifset.2016.10.007
Soldera, S., Sebastianutto, N., & Bortolomeazzi, R. (2008). Composition of phenolic compounds and antioxidant activity of commercial aqueous smoke flavorings. *Journal of Agricultural and Food Chemistry*, *56*(8), 2727–2734. https://doi.org/10.1021/jf072117d
Sunarsih, S. (2020). Pembedayaan masyarakat melalui pemanfaatan komoditas ketela di Desa Giricahyo. *Jurnal Pemberdayaan Masyarakat: Media Pemikiran dan Dakwah Pembangunan*, *4*(1), 193–230. https://doi.org/10.14421/jpm.2020.041-08
Suryani, R., Rizal, W. A., Pratiwi, D., & Prasetyo, D. J. (2020). Karakteristik dan aktivitas antibakteri asap cair dari biomassa kayu putih (*Melaleuca leucadendra*) dan kayu jati (*Tectona grandis*). *Jurnal Teknologi Pertanian*, *21*(2), 106–117.
Swastawati, F. (2011). Studi kelayakan dan efisiensi usaha pengasapan ikan dengan asap cair limbah pertanian. *Jurnal Dinamika Ekonomi Pembangunan*. *1*(1), 18–24.
van Loo, E. J., Babu, D., Crandall, P. G., & Ricke, S. C. (2012). Screening of commercial and pecan shell-extracted liquid smoke agents as natural antimicrobials against

foodborne pathogen. *Journal of Food Protection*, *75*(6), 1148–1152. https://doi.org/10.4315/0362- 028X.JFP-11-543

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