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TRAINING ON BUILDING AND TESTING A SOLAR TUNNEL DRYER TO DRY AGRICULTURAL PRODUCTS AT BULU, KARANGMOJO, KARANGMOJO, GUNUNG KIDUL

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ABSTRACT

Bulu Karangmojo village is a known cashew nut producer central in Gunung Kidul. However, cashew nut farmers faced obstacles in the drying process, especially in the rainy season. An affordable yet simple made solar dryer was essential for the drying process. Our team at UKRIM (Universitas Kristen Immanuel) came up with the solution of using a solar tunnel dryer. The solar tunnel dryer was chosen because people do not need fossil fuels to operate it, so it was more economical, environmentally friendly, and most of the material e.g. wood and bamboo were abundantly and locally available in their village. Moreover, solar tunnel dryer construction was simple enough, so that farmers could make it by themself. Solar energy was used for the drying process. The drying process was using a solar absorber to collect the heat of the sun. The heated air will move to the cashew nuts to absorb the humidity, finally, humid air is leaving through a bug-screen to the environment. Eighteen farmers had actively participated in this training. Finally, a solar tunnel dryer of 5 m length and 1 m width connected with a 10-watt solar panel was successfully constructed. The result showed a 50% faster drying time compared to the traditional sun drying and supplied a higher product quality.

*Keywords***:** *solar drying, solar tunnel dryer, cashew nut, renewable energy*

INTRODUCTION

Karangmojo Village, Karangmojo District, Gunung Kidul Regency has an area of 14,010 Ha with a population of 3,300 households. Agriculture and plantation are the main sources of income in this area. Around 1,649 residents work in the agriculture and plantation sectors. The location of Karangmojo Village is 1 km from the capital of the Karangmojo sub-district and 32 km from the capital of the Gunung Kidul Regency and 33 km from the capital of Yogyakarta Province. Karangmojo village has a very large agricultural land and is managed by 1,356 household production and plantation land managed by 124 household production. All of them consist of 16 hamlets.

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Karangmojo village especially the Bulu area is the center of cashew production which holds most of the harvest in the Gunung Kidul area. Currently, the community can produce approximately 13-15 tons of cashew nuts in the skin (Cashew Nuts in Shell - CNS) or 5 tons of cashews nut per year. The process of drying cashews in Bulu village is done in the traditional methods so that the community often suffers losses due to the non-optimal drying process. In the rainy season, the drying which should last 5 days can become 10 days. From interviews with farmers, it is estimated that 10 percent of cashew nut production is damaged during the drying process. Good quality cashews can be sold at IDR 150,000 per kg. If the drying of cashew nuts is not optimal so the quality is decreased, the price will drop to IDR 90,000 per kg. If the drying process is not optimum, farmers will lose around IDR 30,000,000.00 for every 5 tons CNS they produced.

Instead of cashew, The Bulu area in Karangmojo village also produces various agricultural products such as peanuts, bananas, cassava, ginger, turmeric, ginger, and so on. Therefore, agricultural products need to be dried to preserve agricultural products that are not consumed and increase economic value. In running a business, every process must be done effectively and efficiently. The solar dryer can help the Bulu community in Karangmojo village in maximizing the drying process of existing agricultural products so that the community gets more profit than the previous one.

The drying process is a method of preserving food ingredients without further deterioration of the product which is popular and is often applied in developing countries. Drying is the process of evaporating water contained in food. Drying is first done traditionally in direct sunlight. Along with the development of technology, a drying method that is more effective and efficient compared to traditional drying methods is developed. Solar dryers were categorized into two main parts i.e. conventional and solar energy drying. Solar energy drying was classified into two major groups i.e. passive and active solar energy drying systems. Passive solar energy means conventionally termed natural circulation solar drying system. On the other hand, the most active solar energy is termed a hybrid solar dryer [7].

There are several models of solar dryers that are commonly used, i.e. cabinet dryer, dome dryer, and solar tunnel dryer. In this community service, a solar tunnel dryer model developed by the Institute for Agriculture Engineering in the Tropics and Subtropics of Hohenheim University will be built. Cooperating with Innotech, an engineering company specializing in drying systems, this model was commercially applied in more than 100 countries e.g. Brazil, China, Ghana, India, Indonesia, Turkey, Kenya, Kyrgyzstan, etc. [3].

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Some studies state that the performance of the solar tunnel dryer model is very good for drying capsicum varieties grown in Peru [5] and drying cocoa in Indonesia [2]. The capacity of the solar tunnel dryer depends on its size. For a standard size of 2 m wide and 10 m long, it can dry 100 kg for medical plants and 300 kg for pork, apricots, and coffee [6].

Nowadays, UKRIM's renewable energy laboratory has developed two kinds of solar dryers i.e. solar cabinet dryer and solar tunnel dryer modeled by the University of Hohenheim. Of the two types of solar dryers, the solar tunnel dryer was chosen to be implemented in the Bulu village of Karangmojo village.

The solar tunnel dryer has 3 parts, namely solar collector, dryer section, and airflow system. The air flow is controlled by a fan that uses 10 watts of electricity from the solar panel. Air is pushed into the solar collector by the fan and will be heated by solar radiation. This hot air then flows into the dryer to dry the product. Finally, the humid air is released through vents at the end of the solar dryer.

The expected benefits of community service activities include the community being able to build a solar dryer to dry their agricultural products, the community has experience and understanding that the solar dryer that is built can function well to dry agricultural products. Furthermore, it is hoped that the community will get benefits both economically and environmentally.

METHODS

The target of this activity is the community of farmer groups in Bulu village of Karangmojo, Gunung Kidul Regency. The majority of people who live in Bulu work as farmers and they frequently have to dry agricultural products when the harvest arrives so that these agricultural products can be stored safely and sold at a higher price.

The stages of this community service activity are shown in figure 1. Before carrying out this community service activity we conducted several surveys and interviews with the village head and the head of the farmer group and elders of Bulu village in Karangmojo. From the results of the interview analysis and the survey, it was decided to make a solar tunnel dryer to dry agricultural products, especially cashews. Furthermore, the community development team conducted a literature review regarding the solar dryer model to be built. The model must be easily made, the basic materials are available in the community, economical both in terms of construction and operations, and have an effective performance in drying agricultural products. From the results of the literature review and taking into account the existing requirements then it was decided to make a solar tunnel dryer because this model has been tested and used in more than 100 countries [3].

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The advantage of using a solar dryer is that the drying chamber cannot be penetrated by insects so they cannot pollute and damage the dried material. Secondly, no dust can contaminate it. Third, drizzle does not have a big effect to drying performance and the drying good does not need to be protected from rain, thus decreasing drying time compared to traditional sun drying. The solar dryer can be left unattended so that farmers can do other work. The solar dryer does not require operational costs, it is environmentally friendly and energy self-sufficient [4].

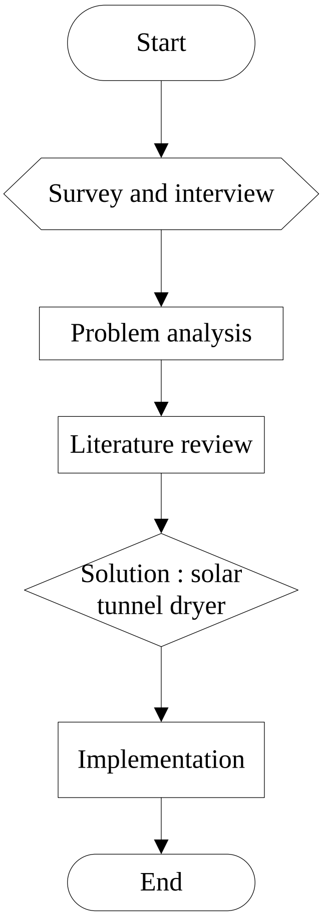

Fig. 1. Community development implementation flow diagram

The next stage was the implementation of the construction of a solar tunnel dryer. Previously, tools and materials were prepared, and time and place of the activity were determined. A visit to Bulu village was carried out to prepare for the activity. During the visit, a discussion was held with the Village Head, and the elders of RUAS (local farmers group) regarding what tools and materials were available in Bulu, what tools and materials the community development team needed to prepare, where was the best location to build a solar tunnel dryer and determine the best time to do this activity. The Head of the Bulu area was in charge of socializing this activity with the residents as well as inviting residents to be actively involved in the planned process.

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On August 1-2, 2018 the construction of a solar tunnel dryer began with the presentation of the theory about solar dryers by community development team. The theory covers the background of why solar dryers are used, what challenges are encountered when drying, how solar dryers work, types of solar dryers, and how to build solar dryers. Previously, they had made a simple handout about these theories and the method of building a solar tunnel dryer so that it was easily understood and applied by the community. Next, the lecturers and workshop participants built a solar power dryer together. The entire community development process took place over 4 months, from May to August 2018. The number of participants involved on the first day was 16 people and the second day was 18 people. In February 2019 a second workshop was held to train the participants how to use and maintain the solar dryer. In this workshop traditional drying and solar drying was compared side by side to gain trust in this new technology.

There are some indicators of the success of this program i.e. the community understands how the performance of the solar dryer, the community can build a solar dryer to dry their agricultural products, and establish good cooperation between the UKRIM with the RUAS farmer group Bulu Village Karangmojo in the field of developing renewable energy technologies that have a positive impact on community progress. The participants experienced that the solar dryer has a faster drying time compared to the traditional drying and higher product quality. Furthermore, some participants want to invest in their own solar dryer.

RESULT AND DISCUSSION

From the results of surveys and interviews with Bulu residents, it is known that the problem they often face is the drying of cashew harvests and other agricultural products. During the rainy season, the drying process which was originally 5 days can last up to 10 days. If the agricultural products are not dried immediately, they can be damaged to cause economic losses. From this problem the community development team decided to make a solar tunnel dryer that can be used without the need for fossil fuels so that it is more economical to operate.

The results in Fig. 2 from the second workshop show, that the solar dryer is around 50% faster than the traditional sun drying (2 days instead of 3 days).

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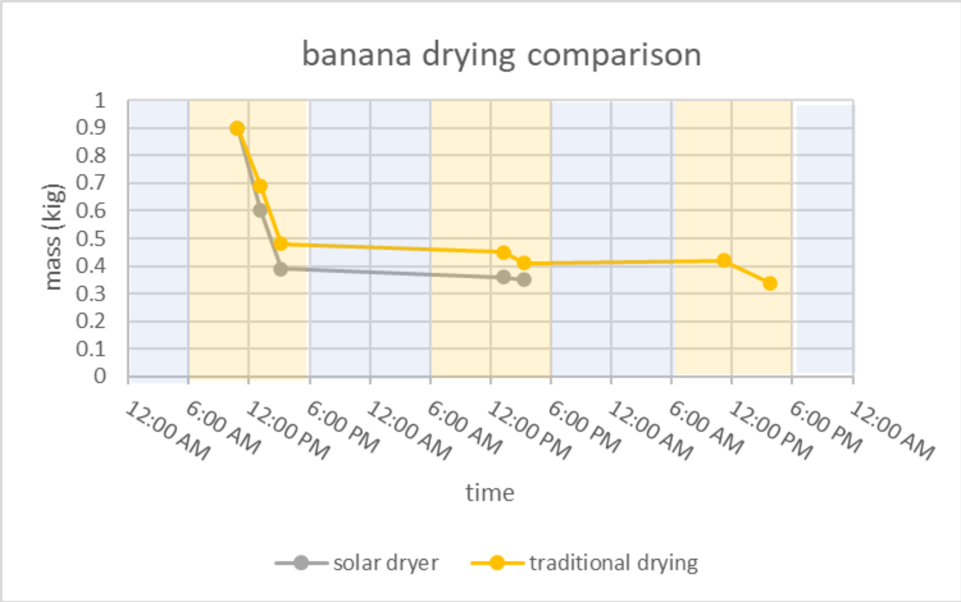

Fig. 2. Comparison of solar drying and traditional drying

A literature study on solar dryer models was conducted. To implement solar drying successfully, solar dryers must be relatively simple to make, the material has to be locally available in Bulu village, easy to maintain, and economical to operate. With these considerations, it was decided to build a solar tunnel dryer. The solar tunnel dryer design is made following the manual "Small solar tunnel dryer" developed by the University of Hohenheim [4] and "Manual training on solar tunnel dryers" developed by the Women Empowerment Program in Nigeria [1]. This solar tunnel dryer has been used in 100 countries to dry various agricultural products [3]. Some parts are adjusted according to available materials, the size of the dryiruang area, the number of fans, and the size of the solar panel. The solar tunnel dryer scheme is illustrated in Figure 3.

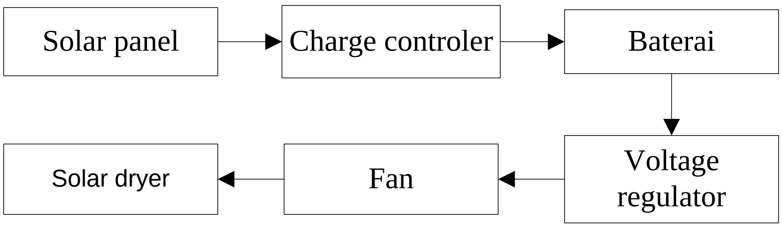

Fig. 3 Solar tunnel dryer scheme

The tools needed to build a solar tunnel dryer are hammers, saws, tape measure, drills, brushes, and screwdrivers. Materials needed to make one unit of solar tunnel dryer with the size of (1 x 5) m are shown in Table 1.

Tabel 1. List of Materials

Material	Size	Quantity
Solar panel	10 W, 18 V	1
Fan DC	12 cm	2

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Cable NYAF	1x0,75 mm	6 m
Iron sheeting	5 x 1 m	1
Wood	4 x 2 cm	30 m
Plywood	0,8 cm width	1
Black paint	½ kg	1
Bug screen	4 x 1 m	1
Nail	4 cm	½ kg
Styrofoam	5 x 1 m	
Screw and bolt	4,5 cm 2 cm	30 10
Charge controller		1
Battery		1
Stepdown regulator	3 A	1

The drying area of the solar tunnel dryer is shown in Fig.4. It was divided into two main parts namely the collector area and the area for drying. From the total area of (5x1) m, the collector area was (1,7 x 1) m and the rest of the area was for the drying material area. This collector area was important because if all of the drying area is covered by material, the result of the drying process will not be uniform. A battery was used to store energy, so the dryer would be able to work at night.

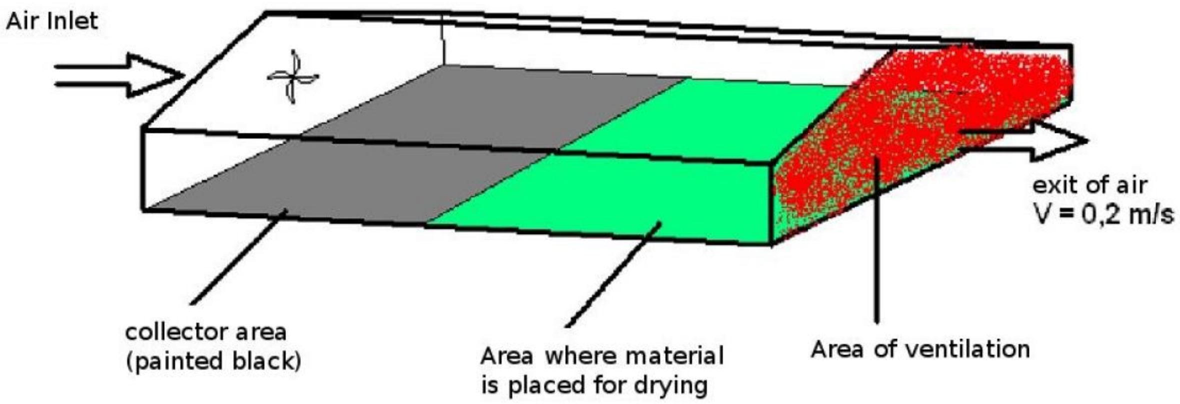

Fig. 4 Drying Area (Hoedt, H., 2005)

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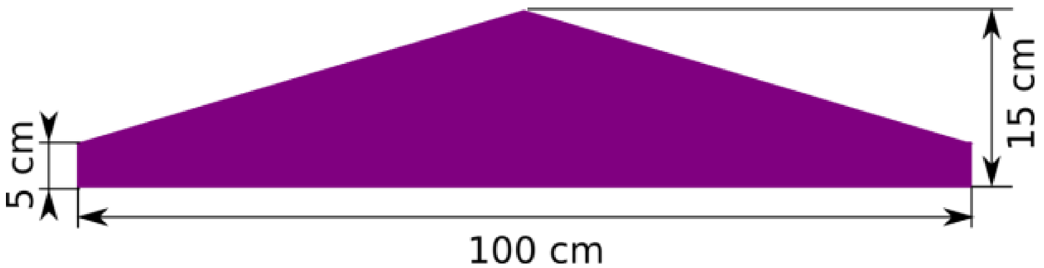

Fig. 5 Roff design (Hoedt, H., 2005)

The design of the solar tunnel dryer roof is shown in Fig. 5. The length of the base follows the width of the solar tunnel dryer that was built. The way these solar tunnel dryers work is that a part of the collector that is painted black will convert sunlight into heat. Furthermore, the hot air becomes relatively dry and then moves to the dryer, where the material is dried to take away the moisture of the dried material. In addition to the hot air collector, the sun's rays on the dried material also help evaporate the water content of the material. The air that has taken moisture from the material then flows out through the ventilation area. Fan power is obtained from electricity produced by solar panels so that the temperature in the solar tunnel dryer is stable. If the intensity of the sun light is strong enough, then the space in the dryer will get hot quickly. The ventilator also serves to drain hot air quickly out to avoid overheating in the drying chamber avoiding lower product quality. Conversely, if the intensity of the sun is weak, electricity from the solar panel will be smaller so that the fan will move more slowly so that the hot air will stay in the drying chamber for longer [4].

During the discussion on the supply of tools and materials, the management of RUAS farmers group that was targeted by workshop, participated proactively to provide the tools and materials that could be obtained in the area, while the tools and materials not available on site were provided by the community development team. The materials provided by the community include metal sheets, wood, plywood, paint, nails, screws, bolts, and gauze. Electronic components such as solar modules, batteries, charge controllers, cables, step-down regulators, and fans were provided by the community development team. The total amount of funds to buy materials to make 1 unit of solar tunnel dryer is Rp. 3,000,000. If the wood and bamboo are already owned by the community, the costs can be reduced to Rp. 2,500,000. To reduce the cost of manufacturing, it can be done by using a solar tunnel dryer without batteries so that if the community uses their wood and bamboo and does not use batteries, the amount of capital needed will be Rp. 2,000,000.00. Solar tunnel dryers without batteries can function only during the day when there is sunlight.

Presentations on drying agricultural products and how to build a solar tunnel dryer were actively followed by the community. This presentation took place with active participation. The participants enthusiastically expressed their opinions and asked questions if they did not understand something.

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The community learned about the theory and methods of the solar tunnel dryer and the community development team learned about the daily challenges faced by the community in drying agricultural products and the potentials of the local area. Besides, the community development team also learned that there is great potential for renewable energy technology to be applied in the village.

We learned that technology implemented in the village should not be sophisticated and difficult to apply but instead the technology should be simple so that the community can learn and make it independently by them self after the workshop is finished.

The final stage of the workshop is the sharing of community impressions and feedback. The community revealed that they were able to build a solar tunnel dryer for the collector area and the dryer frame as it could be done with simple carpentry techniques. The solar modules, batteries, and electronic components are difficult to obtain because the electronic component shop is quite far from their home. The workshop participants were interested in building their solar tunnel dryer at home but are constrained by funds. The team explained that what the team did was training in making solar tunnel dryers, while the problem of providing funds could not be implemented yet. From this discussion, a trainee revealed that she could now understand that what the team was doing was a simple transfer of knowledge and technology that could be applied in her area. The form of assistance does not just fund, but also the knowledge that can be used to solve everyday problems that she encounters. Fig.6 shows the building process of the solar tunnel dryer with the participants.

Fig. 6 Building of the solar tunnel dryer

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In this workshop we learned that this activity can work well with the open communication between our team and the target community and equal relations between us. The success of a program is largely determined by the process of a comprehensive approach in recognizing the problems faced by the community. If the communication process goes well, the community can be actively involved in the activity and feel the real benefits of this activity.

CONCLUSION

A solar dryer for drying cashew nuts and other agricultural products is needed by farmers in Bulu Karangmojo. A solar tunnel dryer was chosen because its construction is simple, does not require fuel to operate because it uses renewable and environmentally friendly solar energy, and has been proven to have a good performance to dry agricultural products in around 100 countries. This solar dryer uses a 10 W solar panel and a battery to store electricity so that the solar dryer can still work at night. The solar tunnel dryer has a size of 1 x 5 m, with 1x 1.7 m being a solar energy collector area. The comparison of the second workshop showed that the solar dryer was performing around 50% faster than traditional sun drying and supplies a higher product quality.

Bulu farmer community has been able to make their own solar tunnel dryers. During the training, they actively participated in the building process. They are motivated that they want to have it in their own homes to dry their agricultural products but were still constrained by funds. The community development team explained that the they provide training on how solar dryers are built and used, but could not yet provide funds to build more solar tunnel dryers. Finally, the community understood that the workshops were contributing the value of knowledge instead of funds. They also realized that this is an important solution for solving their problems regarding drying their agricultural products, especially cashew nuts. Good communication and knowledge transfer in this activity can occur because there was sincerity that both parties meet on eye level and learn from each.

To Improve outcome in further community development programs, a good business model should be introduced so that participants can understand the additional value of the solar dryer.

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