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Increasing Rosella Farmers Capacity by Double Diamond Design Thinking Approach

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Abstract: Rosella (*Hibiscus sabdariffa Linn*) is a well-known family medicinal plant (Toga). Spoilage due to the weather, and the consequent low revenue gained from selling dried rosella are two of the main challenges currently being encountered by rosella farmers. Regardless of previously practicing community engagement including regular training from local authorities, farmers are still encountering difficulties to implement the training materials, consequently experiencing loss. Method incorporated in this community engagement is the double diamond design thinking that ensures putting the farmers first in all stages. Method chosen for drying rosella was a mixed solar dryer equipped with heating lamps and a blower. In addition, a new revenue generating skill was also introduced which included making rosella soap, as the farmers already had access to most of the tools and was a relatively easy process to follow. Farmers were equivalently encouraged to implement the acquired new knowledge as they were involved in every decision-making process, which increased their sense of belonging. After the solar dryer was installed, there were no more spoiled products, and the dried rosella yield was more vibrant in color and shape. Soap production has high conditioning effects and carries potential to bring better revenue compared to selling dried rosella petals. Community intervention can be more fruitful by involving community partner since conception. This program has surpassed the target and partner are happily and willingly continuing the project. This method can be used by other community empowerments doers, especially in horticultural field, as a model for improved farmer knowledge and increased yield, and in the long run to improve national food security.

Keywords: double diamond design thinking; rosella farmers; community engagement; mixed solar dryer; rosella soap.

1. Introduction

Community development must aim to empower community members and use holistic approaches in principles of human rights, inclusion, empowerment, social justice, self-

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determination, and collective action (Smart, 2017). Numerous studies have demonstrated that successfully delivered community empowerment project which even received positive feedback from the community, unfortunately dwindled and failed to sustain in the long run. Hence, community empowerment requires the participation of farmers to not only design the program, but also to further engage as well as seed a sense of responsibility for the success of the program (Hadiyanti, 2008). This community empowerment program chose rosella farmers in Sambikerep region area Surabaya as a partner and subject of the program.

Number of young farmers (25-44 years old) in East Java, Indonesia has proliferated by 148% in the last 5 years (Dinas Komunikasi dan Informatika Provinsi Jawa Timur, 2019). Surabaya as the capital of East Java, a dense metropolitan city with about 3 million people, still consists of approximate 10,000 citizens work with main occupation as farming, working on almost 1,900 Ha of farming land, and 318,4 Ha of which is in Sambikerep area (BPS Jawa Timur, 2020; Dinas Ketahanan Pangan dan Pertanian Kota Surabaya, 2021).

Farmers at Sambikerep area started planting rosella a couple years ago after receiving training, seeds, and seedlings from local health care center (puskesmas) and from Surabaya Food and Agriculture Security Service (*Dinas Ketahanan Pangan dan Pertanian*) regarding family herbal plants (*tanaman obat keluarga* – Toga); hence they called themselves Toga Tani Mandiri. Among several plants, rosella plants, (*Hibiscus sabdariffa Linn*), proliferated dramatically with easy management and produced high yield. These farmers also adhered to applied natural growing methods, opting out chemical fertilizers or plant hormones, insecticides, or other growth regulators. Farmers utilized local pond as the source of water during dry season and incorporated homemade organic compost from agricultural waste (Ali, 2018; Kampustani, 2018; Marzuki, 2018). Problems with planting rosella occurs after harvest. A five-square-meter land can produce about 20kg of rosella flowers per three months and requires expeditious management to prevent decays and fungal growth. Previously, farmers applied direct drying under sunlight and depended solely on the weather for drying. Drying process itself takes three to four consecutive days to dry, should in the middle of that drying time the weather turns cloudy or raining the whole harvest batch will rot and cause crop failure. (Hayati et al., 2012; Hayati, 2011) During the rainy season, farmers are

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supposed to be able to produce more harvest, but post-harvest problems hinder farmers to reap profits up until limiting plants planted. Unstable sun temperature can tamper with the antioxidant level in the flower petals, and direct sun drying method though it is the easiest and cheapest method, can cause lower product quality, by turning dried rosella black and with contamination by dirt, dust, and bacteria. (Veerakumar et al., 2014).

Regularly, the rosella flowers harvested are dried and then sold as well-known products in the community, such as rosella petals tea, ready-made drink, jam, and sweets (Marwati, 2010). Since the rosella sellers has increased, the price of dried rosella has become lower. Processed rosella petals' product could increase product price and revenue compared to dried product but has relatively short shelf time. Hence, farmers have been introduced to other methods to increase revenue with longer shelf storage life by crafting hand soap. During pandemic Covid-19, WHO campaigned hand hygiene as one important thing to prevent infections (WHO, 2020). This campaign could increase the demand of hand soap. Focus of this service is to aid Toga Tani Mandiri farmers in managing their post-harvest rosella product, from drying to processing to reduce wastage and increase revenue.

1.1. Community engagement

Community approach was done by applying a combination of design thinking framework and theory of change. Double diamond design thinking from the Design Council was applied, using 4D method, discover, define, develop, and deliver. Discover stage focuses on partner routine, in this case, how Toga Tani Mandiri farmers manage their products, delving into behavior patterns, their expectations, hopes, and fears. Define stage purpose is to pinpoint the main challenge, brainstorming to determine problem priorities, drivers, and hurdlers. Third stage is developing concepts that suit the user, answering the challenges based on partner needs, resources, and capacity. This step is done by research, followed by various communication with partners regarding the solution, value proposition, cost structure, and revenue it brings (Council, 2019).

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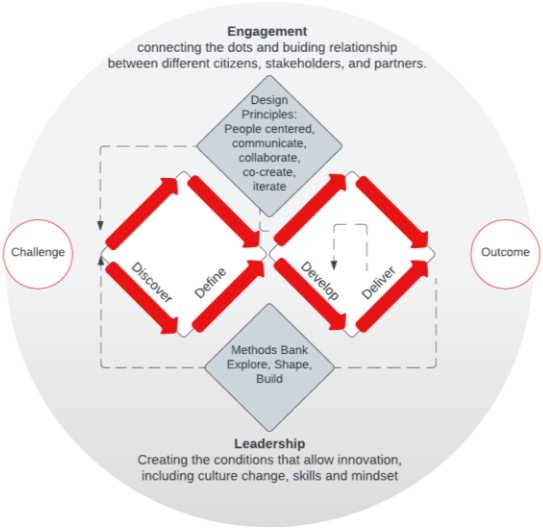

Figure 1. Double Diamond Model Design Process

(Source: Council, 2019)

The final step is to deliver. Once partner agrees on a certain solution, the project is launched followed by evaluation of partner satisfaction, and feedback loops for suggestions and improvement. In this community service, post-harvest handling was defined as one of the challenges.

1.2. Rosella farming

Rosella plants can yield 250–500 kg of dried rosella petals per Ha. A single plant can produce from 1–7 kg of fresh petals, and 90% of its weight will evaporate during drying. Rosella plant is a member of Malvaceae family, and grows well in tropical and subtropical climates, it does not require specific soil nor fertilization. It is an annual shrub, standing straight, ranging from 0.5–5 meter tall (Suherman, 2012). It has a cylindrical and woody stem with many branches. When it matures, the stem turns reddish brown and starts producing flowers. Rosella flowers have 5 petals that are cupped with vibrant red color, the darker the color, the higher the anthocyanin level it contains.

Rosella starts to produce flowers after 120 days and can be harvested regularly every 1–2 weeks for next 3 months before needing to be replaced. It needs 12 hours of sunlight to produce flowers, less than that will end vegetative growth and turn to generative growth. Temperature and humidity also play an important part when flowers

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are starting to bud until harvest as plants need a dry climate. Too much rain or humidity will attract pests and cause root rot. Hence, it needs at least 1 meter space between plants to let airflow. Common pests for rosella plants are red bugs (*Sysdercus cingulatus F*) or locally called "Bapak Pucung" and cotton aphids (*Aphis gossypii*). Pest will feed on flower petals, fruits inside the petals and seeds. Pest also causes a certain odor that ruins the flavor of rosella petals when consumed (Ganjari, 2010; Hardiansah et. al., 2015; Saputro, 2020).

After harvest, rosella petals can be consumed directly as various food and drinks as mentioned above. In India and other countries, other parts or the plants is also processed and consumed; rosella seeds can be used to replace coffee, and the leaves are consumed as green vegetables. The leaves and root also have medicinal properties (Ganjari, 2010). Nevertheless, as other fresh produce, fresh rosella petals only lasts 3 days at room temperature or 7–8 days in the refrigerator before it starts to decay due to its high-water content (Suherman, 2012). Hence to prolong the shelf life, it needs to be dried until petals approximately have only 5% water content.

1.3. Mixed solar dryer

There are three giant groups of drying, there are mechanical methods, electrical methods, and natural convection methods. Examples of mechanical method equipment are rotary dryer, belt, roller, or trays. The electric method uses a dehydrator or oven or spotlight. Natural convection method uses heat as the main component and recirculates naturally because of different temperatures, cultivation of this method adds a drying chamber and airflow system. Natural convection method uses open sun drying, solar tunnel dryer or cabinet dryer. Despite three giant groups of drying, mixed mode dryers that integrate natural convection with other methods could increase the drying efficiency (Veerakumar et al., 2014).

Rosella petals are proven to have various health effects and are part of Toga, because it is easy to plant and maintain. Rosella petals contain anthocyanin that is used as an antioxidant, which could prevent cancer and atherosclerosis (Marnoto et al, 2014). People are familiar with the plant and know rosella's health benefits. Nevertheless, antioxidant levels on each rosella plant are not equal among different farmers due to many reasons, one of them is the drying method (Roshanak et al., 2016). Sun drying is

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one of the cheapest methods and widespread especially in tropical countries (Sahdev, 2014). Nevertheless, sun drying depends solely on weather and various temperatures and sun exposure duration.

Based on information from Toga farmers, drying rosella with direct sun drying takes 3–4 days. Direct sun drying also causes UV damage to plants that could reduce antioxidants inside rosella and active ingredients. In addition, it exposes products to open air which might lead to contamination from dirt, and other microorganisms. Fresh rosella has up to 85% of water content and needs to be reduced to less than 10% for optimal storage. Drying time also needs to be calculated, the higher the temperature the faster water content reduces, but when the temperature is too high flavonoid and anthocyanin in the rosella will be degraded and shown with darker and blackish color (Rahayu et al., 2009).

Solar dryer systems have been developed to resolve limitations of sun drying. Solar drying is using direct sun radiation and greenhouse effect. With a mixed mode dryer, which consists of a fan, solar dryer could reduce the drying time with better end product quality (Ugwuoke et al., 2019). Modification cover material of solar dryers with UV protection could give protection to agricultural products that contain anthocyanins (Rodriguez-Ramirez et al., 2021).

1.4. Rosella soap

Proper handwashing with soap is proven to protect human health from diseases and ensure better health outcomes beyond the pandemic. Soap was often neglected as it is not part of primary needs (clothing, food, and housing), but it is necessary to maintain hygiene and sanitation. Our skin is the largest organ of the human body and important to protect humans from UV damage, microbes, and other harm. Human skin plays an important role in the human system, it absorbs daily physical and environmental changes, takes part in vitamin D absorption, and is filled with thousands nerve endings and vascular capillaries. Key aspects of protection provided by skin are multiple layers of lipids in skin epithelia. Ideal soap must be harsh enough to kill germs, but gentle for the skin. The general purpose of hand hygiene or showering is to reduce exogenous contaminants and skin microbes (Ouellet et al., 2014).

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Soap is a cleansing and emulsifying agent made usually by action of alkali on fat or fatty acids and consisting essentially of sodium or potassium salts of such acid (Merriam-Webster, n.d.). Soap has been around for more than 5000 years since the age of Egypt and Babylonia. During which, animal fats and alkaline plant ash were to generate crude soap which lathered and cleaned effectively (Phanstiel IV et al., 1998).

Soap cleansing properties comes from its ability to solubilizing the insoluble contaminants of dirt, grease, and oil in water; hence it is important to wash your hands with running water to remove all contaminants. Principally, soap is a combination of a triglyceride and an alkali salt in reaction called saponification. Triglyceride can be found from various source, for example, animal fat like beef tallow, or from plant sources, namely, olive oil or cocoa butter. The source of alkali salt used in soap production commonly is one of the following, lye (NaOH), potash (K_2CO_3), and soda (Na_2CO_3).

Types of triglycerides and alkali used contributes to the physical properties of the soap. Soap consistency formed from shorter carbon chain and saturated, will produce a more soluble and lathering soap. For example, soap from coconut or palm kernel oil, that consist more of lauric fatty acid (C12), will produce more foam and lather, compared to soap from olive oil that consist mainly of oleic acid (C18). Soap consistency from natrium alkali tends to be hard because sodium cation is less polarizable and produce a more favorable lactic energy (Konkol & Rasmussen, 2015).

Currently, commercial soap sold in the market are mainly synthetic detergent (syndet) that is made of combination of synthetic surfactants, plasticizers, binders, and other additives. Syndet production began in early 1900 and after the end of 1940s it proliferated as personal hygiene awareness also increased. Syndet is used in both personal care and laundry products (Coiffard & Couteau, 2020). However, there are environmental concern in relation to these products as they have left an insoluble film on the surface of water and potassium content in syndet, which decreased oxygen entry affecting the survival of aquatic species. In Surabaya, this phenomenon can be seen as foams floating in the river and threats the natural biota (Haryono, 2021). Hence, natural soap has gained back its popularity and attained market demands as it addresses both wellness and sustainability (Globally Cool BV, 2020).

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Covid-19 pandemic also emphasized handwashing with soap and running water as part of prevention steps, and many organizations have provided hand washing facilities in public spaces. Alcohol rub can reduce specific number of germs but is not enough when hands are visibly dirty or greasy. It is recommended to wash your hands for minimum 40–60 seconds, with appropriate steps before, during, and after preparing meal or eating; attending baby or children; using the toilet or changing diapers; and even more often now (Kementerian Kesehatan Republik Indonesia & UNICEF, 2020). However, frequent hand washing can decrease lipid barrier and can cause skin dryness and irritation, hence mild soap is recommended to prevent dermatitis (Masood et al., 2020).

Antioxidant in natural soap is required as unsaturated oils in soap is susceptible to lipid oxidation during storage either in curing process or shelf storage. Butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are common additives to prevent this. However, as demands for more natural soap increase, natural antioxidants are more preferred. Rosella has antioxidant levels up to 63% from its active contents, namely anthocyanin, flavonoid, saponin and alkaloid. Rosella also was researched to be an effective sunblock and soap because of its high antioxidant level and antibacterial properties (Gede et al., 2011). Addition of rosella extract will maintain unsaturated oils in soaps; hence the soap can maintain its properties as moisturizing and conditioning for skin, two important properties as during pandemic frequency of handwash increased. Another advantages include reducing bacteria, or yeast growth in soap, naturally reducing final product pH and prolong shelf life of the soap (Adigun et al., 2019).

2. Methods

Community was approached by focus group discussion to discover pain, gain, and expectations from the service. This process was carried out from September 2019 to January 2020. It was discovered that rosella farmers' at Sambikerep Surabaya need was regarding post-harvest handling, especially product preservation, for both non-processed and processed roselle petals. There were two solutions delivered, the first one was crafting a dryer to solve decay and fungus problems. Second one to increase farmers revenue by simple method of roselle petals processing to soap bars, that has a longer shelf life compared to roselle based food product.

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In this community service, the technology used to dry rosella petals is a mixed method of direct and indirect type of drying, where the product is exposed to direct sunlight and the drying chamber which is kept dry and warm by using additional lamps. Air circulation in the chamber is also maintained by a mixed mode of natural and forced circulation using a blower. Solar dryer improves the qualities of rosella namely better moisture content, color, and vitamin C (Ali et al., 2016). Solar dryer was made using polycarbonate with UV protection to prevent damage of antioxidants during drying processing. After the survey, the team decided to make a 1,9 m x 1 m solar dryer with modification by adding some lamps and blower fans.

Soap making workshop delivered the cold soap process. Tools incorporated were namely stainless-steel utensils, bowls, spoon, measuring cups, weighing scale, immersion blender, and used milk containers as soap mold. Materials used were NaOH, roselle petals, a combination of coconut, palm, and olive oil, with addition of cocoa butter.

3. Results and discussion

Community service was initiated with a visit to Toga Tani Mandiri. Following which a brainstorming session was conducted to discuss the existing issues. It was found that rosella requires air drying for at least 3 days and if disturbed during rain or cloudy weather, it will decay with fungi. On the other hand, the production of rosella is for food and beverages only currently and needs expansion in terms of varieties of products. For resolution, Universitas Ciputra Surabaya team chose to develop a mixed mode dryer and varieties of rosella products.

The development of mixed mode dryer was a consolidation between a natural convection method that utilized the sun and an electric method that utilized both fan and lamp. On December 7th, 2019, Team went to Toga Tani Mandiri's drying place to survey the current drying condition (Figure 2). Total area that was used for drying was 6,2 m x 2,8 m. Toga Tani Mandiri are utilizes tarp as a base tray for rosella. Should the weather condition be not optimum for crop drying, Toga Tani Mandiri's person will move the tarp and rosella to the house. This process is not only tiresome but also requires continuous monitoring along the drying process. They also had tried to use an oven for

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drying but it had charred and could not be sold. The size of the dryer was decided upon consideration of people's mobility and the capacity of the dryer (Figure 2).

a  b 

Figure 2. (a): Measurement of drying area; utilizing the roof of one of the farmers' houses to get as much sun as possible. (b) Finished product of modified solar dryer

One week after installation, the team evaluated the drying process of rosella. Farmer reported the drying time was the same between direct sun drying method and using the solar dryer which is three to four days, with an exception that there was one rainy day in between the drying process and the rosella petals are completely dried with no decay. Farmer said the blowers were used once on a rainy day. Since the dryer has a roof that protects the rosella, it was more convenient than using open sun drying. The dried rosella using modified solar dryers is also brighter than using open sun drying (Figure 3).

Figure 3. Dried Rosella (Left: solar dryer; right: sun drying). Visually there is quality difference between solar and direct sun drying, the end product of solar drying is more vibrant in color and shape in comparison to sun drying.

During dehydration there are inter-related factors that control the capacity of air to remove moisture namely the amount of water vapor carried by the air, the air

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temperature, and amount of air that passes over the food (Fellows, 2000). The drying temperature in the solar dryer was evaluated, including with and without lamp. With lamps, the temperature increased around 3°C higher in comparison to without lamps, however after calculation there was no difference in the total moisture content carried by air (±0,012–0,014 kg/kgDA). The result demonstrated that utilization of lamps during sunny days was pointless and can potentially cause more damage to the antioxidant content of rosella, therefore, the lamp is kept for solar dryer use during rainy weather. The moisture content of rosella with the solar dryer was 10,08% whereas the moisture content of rosella with sun drying technique was 13,3%. The vitamin C of rosella with solar dryer (81,2 mg/g (wb)) was also higher in comparison to the sun drying technique (71,67 mg/g).

The next process was the introduction of non-food rosella products. The basis of soap making is saponification process, a mixture of acid (oils) and sodium hydroxide as base. The reaction produces salt (soap), glycerin, and water (Wolf & Parish, 2012). Sodium hydroxide (NaOH) was diluted with water and then allowed to cool for about 30 minutes. The cocoa butter was melted in water bath and then mixed with other oils. When the temperature difference of oils and NaOH temperature reached less than 10^{o}C, the solution was mixed with hand blender, until the color turned opaque. Rosella extract was weighed and added to the mixture and was blended until homogenous and hint of ribbon or trace was visually observed. The mixture was then transferred to molds lined with parchment paper and decorated with rosella petals on top, followed by little spray of 70% alcohol. After 24 hours, soaps were set, cut to desired size, and laid out to cure for 4–6 weeks in airy and dry space without direct sunlight. After curing process, soap pH was tested by diluting small amount of soap and water, pH below 10 is acceptable for natural soap.

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a  b 

Figure 4. (a) Depicts the soap making process where farmers were introduced to cold process soap making. Farmers already have almost all the utensils and materials needed to make soap (b) un-cut soap result

Soap ingredients were analyzed using soapcalc.net. Analysis reveals that it has a saturated: unsaturated ratio of 52:48, the main component is oleic (38%), followed by palmitic (23%) and lauric acid (14%).

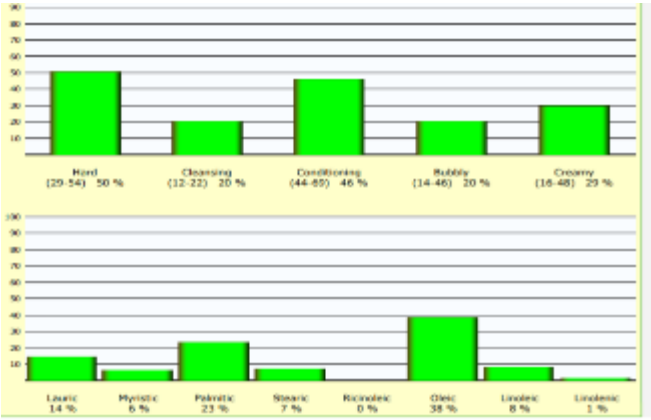

Figure 5. Soap analysis

Higher oleic oil in the soap indicates higher unsaturated bonds content and are very conditioning with better absorption but creates a softer product compared to commercial soap. The palmitic acid contributes to hardness of the soap, lathering properties and slows oxidation (Oghome et al., 2012). Cocoa butter adds polyphenols which also have free radical scavenging activities, it also supports the soap physical properties by slowing fat oxidation in addition to acting as a stabilizer (Singh et al., 2020).

Rosella soap also brings better revenue for the farmers in comparison to the unprocessed dried rosella. In the market, dried rosella only sells for Rp.15.000–20.000, -/100 grams. With rosella soap, the capital is less than Rp. 8.000, -/per 100 grams of bar

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soap and in the market, organic homemade soap is valued for Rp.20.000,- and above, potentially earning higher revenue for the farmers.

4. Conclusion

Community engagement program, as its name suggests, requires not only the involvement of the community, but also requires their first establishment in the decision-making process. There is numerous community empowerment that includes better technology and offers better yield from various sources, yet farmers either cannot keep up with the knowledge and skills transferred or are not comfortable implementing them, hence the newfound knowledge was abandoned. With continuous discussion, education, and community involvement, the program can prove to be beneficial for both parties. Rosella is a well-received horticultural produce in Indonesia. Proper harvest handling will prevent wastage during storage, consequently increasing yield.

Drying technique has been utilized for centuries and has proven to be effective for lengthening the storage time. Lowering water and moisture content reduces products' tendency to rot and therefore allowing produce to be stored in room temperature for longer period. Basic solar dryer without blower lamp is adequate during dry and sunny season. The difference from direct sun drying is the polycarbonate trays are above ground, hence at night they are not exposed to cold floor and the polycarbonate roof protects the product from UV damage. During the rainy season, solar dryer needs to be equipped with a lamp and blower to maintain humidity and temperature in the drying chamber. Products dried with solar dryer bring more vibrant results and hold product's shape better in comparison to sun drying.

Our skin requires consistent care to function as the barrier and protector. The most fundamental way of skin care is regular showering with gentle soap. Rosella soap made in this service is made with natural ingredients and rosella petals enhances antioxidant and antibacterial properties of the soap. Cold process soap making has been proven easy to do and farmers can independently recreate the soap making process with various molds. However, the main drawback encountered by the farmers is the curing time of the soap making process that consumes 4–6 weeks. Another request received from the farmers is addition of more workshops regarding product packaging and marketing.

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Declaration of Conflicting Interest

Author has no conflict of interest to declare.

Author Contribution

Pribadi Florence as the leader of this community service team was responsible for drafting and substantive revision of the work. Kartikawati Muliasari, contributed mostly on innovating the mixed solar dryer, its installation, and for drafting paragraph regarding solar dryer. On the other hand, Njoto Julikarijati, contributed in making of soap and the components needed for healthy skin. Sari Nurul Illahi Kusuma and Nur Farah Shania were responsible for initial discussion.

Short Biography

Florence Pribadi is a lecturer at School of Medicine, she received her bachelor's and master's degree from the Faculty of Medicine Airlangga University. Her current field of placement is Department of Pharmacology with research interest in developing herbal medicine.

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Njoto Julikarijati, is a lecturer at the School of Medicine, she received her master's degree in Biomedics and Antiaging Medicine from Faculty of Medicine, Udayana University. Her interest is in antiaging.

Sari Nurul Illahi Kusuma, and **Nur Farah Shania** are fourth year students at the School of Medicine. They have been in contact with rosella farmers since year two of this research, and their undergraduate thesis topic is rosella.

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