

DUKU PEEL INNOVATION: EFFORTS TO IMPROVE CREATIVE HEALTHPRENEURS THROUGH THE DEVELOPMENT OF PLANT-BASED INSECTICIDES

Miftahurrahma Miftahurrahma¹, Tengku Arief Buana Perkasa², Huntari Harahap³, Hafizah Hafizah⁴, Denok Tri Hardiningsih⁵, I Made Dwi Mertha Adnyana⁶

¹Department of Surgery, Faculty of Medicine and Health Sciences, Universitas Jambi, 36361, Jambi, Indonesia

²Department of Biochemistry and Medical Biology, Faculty of Medicine and Health Sciences, Universitas Jambi, 36361, Jambi, Indonesia

³⁻⁵ Department of Fisiology, Faculty of Medicine and Health Sciences, Universitas Jambi, 36361, Jambi, Indonesia

⁶Department of Medical Professions, Faculty of Medicine and Health Sciences, Universitas Jambi, Jambi, Indonesia

⁶ Associate Epidemiologists, Indonesian Society of Epidemiologists, Daerah Khusus Ibukota Jakarta, Indonesia

⁶Royal Society of Tropical Medicine and Hygiene, London, United Kingdom

Email: ¹ miftahurrahman_fkik@unja.ac.id, ² tengkuariefbuanap@unja.ac.id, ³ huntariharahap@gmail.com, ⁴ hafizah91@unja.ac.id, ⁵ denoktrihardiningsih@unja.ac.id, ⁶ i.madewimertha@unja.ac.id

Corresponding Author Email: miftahurrahman_fkik@unja.ac.id

Abstract

Duku peel is an underutilized agricultural byproduct in Talang Duku Village, a major center of duku production, and is commonly discarded as waste. The community's heavy reliance on synthetic chemical insecticides presents environmental and health risks, compounded by limited knowledge regarding the processing of agricultural waste into value-added products. This community service program aimed to empower the "A. Khalik Duku Plantation" Farmers Group by converting duku peel waste into a high-value plant-based insecticide in the form of aromatherapy candles, thereby fostering a new generation of creative healthpreneurs. The program applied a participatory community empowerment approach through education, hands-on training, and continuous mentoring. The stages included needs assessment, production and business management training, and evaluation using pre-test and post-test data analyzed with the Wilcoxon and Chi-Square tests. The results showed a significant improvement in participants' knowledge ($P < 0.001$), with the median score increasing from 70% to 80% and the number of participants achieving the $\geq 80\%$ competency threshold rising from 13 to 49. Furthermore, the program successfully facilitated the production of insect-repellent aromatherapy candles and the establishment of the "KUB Duku Lestari" Joint Business Group, which sold more than 50 units within the first three months. In conclusion, this program effectively transformed agricultural waste into a valuable product, promoted sustainable entrepreneurship, and contributed to improving community welfare. It is recommended that the business group standardize product packaging to enhance market competitiveness and that future studies focus on optimizing extraction techniques to improve product efficacy.

Keywords: creative healthpreneur; duku peel; plant-based insecticide; community empowerment; aromatherapy candles.

Abstrak

Kulit duku merupakan produk samping pertanian yang belum dimanfaatkan secara optimal di Desa Talang Duku, salah satu sentra penghasil duku, dan umumnya dibuang sebagai limbah. Ketergantungan masyarakat terhadap insektisida kimia sintesis berpotensi menimbulkan dampak negatif terhadap lingkungan dan kesehatan, yang diperparah oleh keterbatasan pengetahuan dalam pengolahan limbah pertanian. Program pengabdian kepada masyarakat ini bertujuan untuk memberdayakan Kelompok Tani “Perkebunan Duku A. Khalik” melalui pemanfaatan limbah kulit duku menjadi insektisida nabati bernilai ekonomi tinggi dalam bentuk lilin aromaterapi, sehingga mampu menumbuhkan creative healthpreneur baru. Metode yang digunakan adalah pemberdayaan masyarakat partisipatif melalui kegiatan edukasi, pelatihan, dan pendampingan. Tahapan kegiatan meliputi analisis kebutuhan, pelatihan produksi dan manajemen usaha, serta evaluasi menggunakan data pre-test dan post-test yang dianalisis dengan uji Wilcoxon dan Chi-Square. Hasil kegiatan menunjukkan peningkatan pengetahuan peserta yang signifikan ($P < 0,001$), dengan skor median meningkat dari 70% menjadi 80% dan jumlah peserta yang mencapai nilai $\geq 80\%$ bertambah dari 13 menjadi 49 orang. Program ini berhasil menghasilkan produk lilin aromaterapi pengusir serangga serta membentuk Kelompok Usaha Bersama (KUB) “Duku Lestari” yang mampu menjual lebih dari 50 unit produk dalam tiga bulan pertama. Dengan demikian, program ini efektif dalam mengonversi limbah menjadi produk bernilai, membangun ekosistem kewirausahaan yang mandiri dan berkelanjutan, serta meningkatkan kesejahteraan masyarakat. Disarankan agar kelompok usaha melakukan standardisasi kemasan guna meningkatkan daya saing produk dan dilakukan penelitian lanjutan untuk mengoptimalkan teknik ekstraksi sehingga efikasi produk semakin meningkat.

Kata kunci: creative healthpreneur; kulit duku; insektisida nabati; pemberdayaan masyarakat; lilin aromaterapi.

1. INTRODUCTION

The development of plant-based insecticides represents a promising field for innovative health entrepreneurs, particularly when innovative raw materials such as duku (*Lansium domesticum*) peel are considered. Duku peel, a largely underutilized agro-byproduct, offers an eco-friendly alternative to conventional synthetic insecticides that are often associated with environmental hazards (Isman, 2015a). Demonstrated insecticidal properties of duku peel extract against pests such as bed bugs have been observed, indicating its potential to serve as a bioactive ingredient in the formulation of natural insecticides (Darmadi, 2021). Further exploration of bioactive compounds within duku peel aligns with research showing that compounds from this plant exhibit notable cytotoxic and biochemical activities (Fadhilah et al., 2021), suggesting that the peel contains a diverse array of active molecules suitable for multi-target applications in pest control and beyond.

Talang Duku Village is one of the most strategic villages and serves as a benchmark for the economy of Jambi Province. Talang Duku Village is located in the Taman Rajo Subdistrict of Muaro Jambi Regency in Jambi Province. Talang Duku Village consists of four hamlets with a total population of 4,159. This village is known as one of the centers of duku production in Jambi, with many farmers relying on this fruit as their main source of income (Website Resmi Desa Talang Duku, 2025). Duku fruit not only has high economic value as a fresh fruit commodity but also has other potential that has not been optimally utilized, namely duku peel. Duku peel has often been discarded as agricultural waste, even though several studies have shown that it contains bioactive compounds, such as flavonoids, tannins, and saponins, which have antimicrobial and insecticidal properties. This potential opens up opportunities to convert

duku peel waste into environmentally friendly natural mosquito repellent insecticides (Januariana et al., 2018). In addition to environmental and health aspects, this innovation is also in line with the concept of creative health entrepreneurship, which is an entrepreneurial approach that combines creativity, health, and community economic empowerment. By developing natural insecticides from duku peel, farmers in Talang Duku Village can not only reduce agricultural waste but also create value-added products that can increase their income.

The urgency of community service on “Duku Skin Innovation: Efforts to Improve Creative Entrepreneurship Health through the Development of Botanical Insecticides” is further reinforced by the need to address the pressing environmental, economic, and social challenges currently faced by local and global communities (Catahan, 2024). In the current socio-economic context, the integration of innovative botanical insecticides into community practices is not only a technological challenge but also a critical necessity for sustainable natural resource management (Afrianto et al., 2022; Dougoud et al., 2019). This research initiative directly responds to the Sustainable Development Goals (SDGs), which aim to promote sustainable agriculture, support healthy ecosystems and reduce dependence on synthetic chemicals (Catahan, 2024; Isman, 2015b). Furthermore, by integrating botanical innovations into community service, this project encourages inclusive participation and strengthens the local economy through creative entrepreneurial health (Febrian et al., 2023; Hz et al., 2023). The link between environmental conservation and economic empowerment serves as a timely reminder of the critical role of community service in promoting sustainable development and resilience (Catahan, 2024; Isman, 2015b).

This research is urgent because it involves the development and application of botanical insecticides derived from duku peel, an agricultural waste product that has not been widely explored but has great potential for innovation and sustainability (Afrianto et al., 2022; Dougoud et al., 2019). Botanical insecticides have emerged as safer alternatives with lower environmental impact than synthetic pesticides, making them highly relevant in an era of increasing environmental awareness and regulatory scrutiny (Dougoud et al., 2019; Isman, 2015b). In the context of community service research, exploring innovations such as this provides direct benefits to local communities through reduced exposure to harmful pesticides and improved crop protection (Afrianto et al., 2022; Catahan, 2024). Furthermore, by utilizing traditional knowledge of plant-based products, this initiative preserves local wisdom and is in line with global biodiversity conservation efforts (Afrianto et al., 2022; Dougoud et al., 2019). This approach embodies the integration of scientific rigour and community empowerment, offering a replicable model for sustainable rural development (Catahan, 2024; Isman, 2015b).

The selling price of fresh duku fruit is IDR 10,000–15,000/kg. One kilogram of duku fruit produces approximately 0.3 kg of peel, which becomes waste during the duku fruit season (Ayudia et al., 2022; Miftahurrahmah et al., 2022). Target partners have great potential to become creative healthpreneurs through the utilization of the duku peel waste, with the support of technological innovation and continuous guidance. There is a lack of knowledge regarding the processing of duku peel waste into value-added products. This situation analysis shows that the Duku Farmers Group has great potential for developing natural insecticides from Duku peel. However, they also face various problems that need to be overcome in terms of production, marketing, and regional conditions. With the right support, this innovation can improve the welfare of farmer group members and make a positive contribution to the environment.

2. RESEARCH METHOD

This community service program was implemented using a participatory community empowerment method that focused on education, training, and technological assistance. The activities were carried out in 2025, with the target partner being 'A. Khalik duku plantation' Farmers Group in Talang Duku Village, Taman Rajo Subdistrict, Muaro Jambi Regency. The program implementation was divided into several systematic and interrelated stages to address the priority issues in production and management faced by the partners.

The initial stage began with a needs analysis through surveys and in-depth discussions with farmer groups to map their initial understanding, challenges, and expectations regarding the use of the duku peel waste as a natural insecticide. The core stage of the activity was training and technology applications. The training was designed to improve the partners' technical skills in production, covering material on bioactive compounds in duku peel, simple extraction techniques, formulation, and hands-on practice in making plant-based insecticides in the form of aromatherapy wax. Furthermore, the program continued with a period of assistance and periodic evaluation. The implementation team, together with the students, provided direct assistance during the production process and tested the effectiveness of the product in the field to ensure that it could significantly reduce the mosquito population.

The analysis of pre- and post-test data in this community service activity began with a normality test using the Shapiro-Wilk test. Normally distributed data are presented as mean \pm standard deviation (SD), whereas non-normally distributed data are presented as median (range). To analyze the differences between pre- and post-test scores, a paired t-test was used for normally distributed data, or a Wilcoxon signed-rank test for non-normally distributed data. Furthermore, pre- and post-test scores were categorized as 'pass' and 'fail.' Participants were categorized as passing if they obtained a score of $\geq 80\%$. The difference in the proportion of passing between the pre- and post-tests was analyzed using the Pearson Chi-Square test. However, Fisher's Exact Test was used when the expected value was < 5 . The statistical significance level for all tests was set at $P < 0.05$. The satisfaction survey results are presented in a descriptive form.

3. RESULT AND DISCUSSION

1.1. Initial Stage: Raising Awareness through Needs Analysis and Socialisation

In the initial stage, a needs analysis was conducted through a pre-activity survey and Focus Group Discussion (FGD) with members of the farmer group. The survey results showed that none of the members had ever utilized duku peel waste and considered it worthless rubbish. All members still relied entirely on synthetic chemical insecticides to control pests and mosquitoes in their environments. Nevertheless, 100% of respondents expressed a high level of interest in learning about innovations in waste processing into value-added products if they were provided with guidance. All partner members and more than 15 other villagers successfully attended the socialization activities that were organized. The response received was very positive, marked by the enthusiasm of the participants in the question-and-answer session and requests to immediately implement the training.



Figure 1. Documentation of pre-activity socialisation activities

The data from this needs analysis strongly validate the urgency of the proposed program. The high dependence on chemical insecticides is consistent with the initial situational analysis, which identified potential environmental pollution and health risks. These findings confirm that the proposed intervention is on target, as it addresses the real problems faced by the partners. The success of the socialization phase is key to building trust and commitment to participation by partners. A communicative approach and simple demonstrations of the potential of Duku peel proved effective in changing the initial perception of waste as a resource. This is in line with the principle of empowerment, where a change in mindset is the foundation for adopting sustainable technology and innovation.

1.2. Core Stage: Knowledge and Technology Transfer through Intensive Training

The core phase focused on two main training sessions: training in the production of botanical insecticides and training in business management. During the production training, participants were provided with information about the bioactive compounds present in duku peel, such as alkaloids and flavonoids, and hands-on practice in making insect repellent aromatherapy candles. All participants successfully produced their first batch of aromatherapy candles according to the standards taught. Furthermore, in business management training, 100% of the participants successfully compiled a simulation of production cost calculations, determined selling prices, and created simple business plans for their products. In addition, there was a handover and training on the use of appropriate technology, such as electric ovens and grinding machines. Evaluation through pre-tests and post-tests showed a significant increase in participants' knowledge ($P < 0.001$), with the median understanding score increasing from 70% (30%-100%) to 80% (40%-100%). To further confirm the success of this training and determine the number of participants who passed the training with a level of understanding above or equal to 80%, the number of participants who passed and did not pass was calculated. An evaluation of the pass rate with a level of understanding above or equal to 80% showed that this activity succeeded in increasing participants' understanding by at least 80%, from 13 out of 71

participants initially to 49 out of 71 participants. A comparison of the pre- and post-test scores is presented in **Table 1**, while the number of participants who passed and failed the pre- and post-test (cut-off score $\geq 80\%$) is presented in **Table 2**.

Table 1. Pre-test and Post-test score

Test Activity	Score (n=71, %)	P value
Pre-test	70 (30-100)	<0.001*
Post-test	80 (40-100)	

* The data was not normally distributed, so it was presented in median (range) and the Wilcoxon test was used. The significance level used was $p < 0.05$.

Table 2. Number of participants who passed and failed the pre-test and post-test (cut off score $\geq 80\%$)

Test Activity	Passed (n)	Failed (n)	P value
Pre-test	13	58	<0.001*
Post-test	49	22	

* Analysis using Pearson Chi-Square Test with a significance level of $p < 0.05$

The dramatic increase in knowledge and skills demonstrates the effectiveness of participatory and applied training methods (learning by doing). The participants' success in independently producing aromatherapy candles is a crucial achievement that directly addresses issues related to production. The introduction of appropriate technology serves as a tool and a catalyst for product efficiency and standardization. The use of electric ovens ensures that the maceration and drying processes of duku peel run optimally without damaging the active compounds, while grinding machines guarantee the consistency of the raw materials. This is an important step in transforming activities from a household scale to a more professional business level. Specific business management training addresses weaknesses in management, equipping partners with an entrepreneurial foundation to ensure that product innovation is balanced with business viability, in line with the goal of creating creative healthpreneurs.



Figure 2. Documentation of training on making anti-insecticidal duku peel candles

1.3. Advanced Stage: Product Validation and Capacity Building through Mentoring and Evaluation

During the advanced phase, the implementation team conducted regular visits to facilitate the production process and problem-solve. Product effectiveness trials were conducted in 10 partner members' homes over four weeks. Qualitatively, 95% of users expressed satisfaction with the product's effectiveness and liked its therapeutic aroma. Periodic evaluations conducted every three months identified that the partners were able to produce consistently but faced challenges in terms of packaging standardization and access to attractive packaging materials.



Figure 3. Documentation of mentoring activities with residents of Talang Duku village

The results of product trials that exceeded the targets provided empirical evidence that the innovation of plant-based insecticides from duku peel is effective and worthy of further development. The product's advantage of not only functioning as an insecticide but also providing a relaxing effect through aromatherapy is a very important value proposition in marketing strategy. This is the essence of the creative healthpreneur concept, which is to create products that provide solutions to health problems (mosquitoes) but are packaged creatively and modernly. The identification of packaging-related challenges during the evaluation highlights the importance of the mentoring process. This enables the team to provide relevant solutions, such as connecting partners with SME packaging providers, so that problems can be overcome before they hinder the growth of the business.

1.4. Sustainability Phase: Business Institutionalisation and Network Expansion

As the culmination of the empowerment program, the formation of a Joint Business Group (KUB) named 'KUB Duku Lestari' was successfully facilitated. KUB have established an organizational structure, a joint cash system, and a collective product brand. With digital

marketing assistance, KUB successfully created social media accounts and a simple product catalogue. In the first three months after intensive training, KUB managed to sell more than 50 units of products through direct sales at the village level, local orders, and online promotions. The formation of the KUB is a strategic achievement that is key to the program's sustainability. This institutionalization has transformed farmers from individual producers into a stronger and more organized collective business entity. The existence of KUB facilitates production management, quality control, and joint marketing strategies, thereby improving their bargaining position in the market and increasing their income. The initial sales figure of 50 units is a clear indicator of the program's direct economic impact, proving that this innovative product is accepted by the local market. Proactive steps in establishing cooperation with relevant agencies demonstrate the KUB's long-term vision. This opens up opportunities for wider market access, further guidance, and potential business legality, ensuring that this community service program does not end as a project but becomes the forerunner of a new, independent, and competitive entrepreneurial ecosystem in Talang Duku Village.



Figure 4. Documentation of finished products made from duku peel as an insecticide

1.5. Future Prospects

Integrating this innovation within a health entrepreneurial framework entail leveraging both modern scientific extraction techniques and traditional local wisdom. For instance, models that integrate local knowledge with project-based learning (PJBL) have already been successfully applied to medicinal plant processing in regions like Talang Duku Village (Nirmala et al., 2024). Such approaches promote the sustainable management of valuable plant resources and empower local communities by linking traditional practices with contemporary market opportunities. Studies on citrus peel and other plant materials demonstrate that extraction methods including the use of ethanol and nano-formulation techniques can enhance the bioavailability and stability of insecticidal compounds, thereby improve efficacy while preserving environmental integrity (Ahmed et al., 2023; Simon-Oke & Akeju, 2019; Ukpong Iniodu George, 2019).

The scientific community increasingly recognizes the superior environmental profile of botanical insecticides over synthetic chemicals. Research reviews indicate that these products tend to degrade more rapidly, exhibit lower toxicity to non-target species, and mitigate the risks associated with widespread insecticide resistance (Silvério, Espindola, et al., 2020). In this context, duku peel innovation resonates with the shift toward eco-friendly and sustainable insect pest management strategies. Comparative studies involving citrus essential oils and other plant extracts further substantiate that fruit peel extracts can effectively control insect vectors, providing a conceptual framework for the potential use of duku peel in local insecticide formulations (Pei et al., 2023).

Moving forward, the development of duku peel-based insecticides requires multilevel research to optimize extraction techniques and validate field efficacy. This includes the characterization of its chemical components through advanced chromatography and spectroscopy methods, which has shown promise in analogous studies on duku and other fruit peels (Fitri & Ardiansyah, 2023). Additionally, the potential to enhance formulation stability through nano-encapsulation, as demonstrated in citrus peel studies, points to a future where duku peel formulations might be tailored to meet specific pest-control challenges across diverse environmental settings (Ahmed et al., 2023; Sivapunniam et al., 2024).

The peel of *Lansium domesticum* contains a diverse array of bioactive constituents that contribute to its insecticidal properties. Research has identified that duku peel extract is replete with bioactive compounds including flavonoids and alkaloids which are recognized as key phytochemical classes with established biological activities. The presence of these secondary metabolites in duku peel aligns with the broader understanding that plant-derived bioactive compounds can serve as effective alternatives to synthetic pesticides (Chaudhary et al., 2024; Deliza et al., 2025). The chemical composition of duku peel extracts varies depending on the extraction methodology employed. Different solvent systems, such as ethyl acetate, have been utilized to isolate and concentrate bioactive compounds from duku peel (Rahman et al., 2025). This variation in extraction techniques is significant because the solvent choice directly influences the phytochemical yield and the concentration of active compounds available for insecticidal applications (Munuo et al., 2025).

Duku peel extract has demonstrated larvicidal activity against *Aedes aegypti*, a primary vector of arboviruses including dengue, Zika, and chikungunya (Putri et al., 2024; Silvério, Espindola, et al., 2020). The secondary metabolite compounds present in *Lansium domesticum* have been proven to possess the potential to act as insecticides making duku peel a candidate for vector control strategies. This activity is particularly significant given the increasing resistance of mosquito populations to traditional synthetic insecticides and the environmental concerns associated with conventional pesticide use (Putri et al., 2024; Silvério, Espindola, et al., 2020).

Beyond mosquito vectors, duku peel extract has shown efficacy against additional arthropod pests. Research has demonstrated that duku skin extract possesses insecticidal properties effective against *Pediculus humanus capitis* (head lice), with studies specifically designed to determine the mortality rates of this parasitic insect and to identify the specific compounds responsible for this activity (Darmadi et al., 2018). This broader spectrum of activity suggests that the bioactive compounds in duku peel may have multiple mechanisms of action affecting different arthropod species.

The insecticidal mechanisms of action attributed to plant-derived bioactive compounds, including those found in duku peel, operate through multiple pathways. Essential oils and plant extracts containing volatile molecules such as terpenes, terpenoids, and phenol-derived aromatic components have demonstrated significant insecticidal potential. These compounds function as ovicidal, larvicidal, and adulticidal agents while also exhibiting repellency, antifeedant, and growth and reproduction inhibitory properties (Gnankiné & Bassolé, 2017). The flavonoids and alkaloids identified in duku peel represent important classes of bioactive compounds known to disrupt crucial arthropod life cycle pathways. Similar bioactive compounds found in other tropical plants, including flavonoids, terpenoids, saponins, and phenolic acids, have been documented to exert larvicidal, insecticidal, and repellent activities through involvement with insect digestion, hormonal balance, and neural pathways (Deliza et al., 2025; Rani et al., 2025).

While the specific pyrethroid-like mechanisms of duku peel compounds have not been extensively detailed in the available literature, the insecticidal properties of duku peel extract align with the broader category of botanical insecticides that serve as alternatives to synthetic pyrethroids. Essential oils and plant-derived bioactive compounds are increasingly studied as bioinsecticides because they are renewable, natural, biodegradable, non-persistent in the environment, and safe to non-target organisms and humans (Garrido-Suárez et al., 2022). These characteristics make them suitable alternatives to synthetic pyrethroids, which have become a concern for human health and the environment due to their toxic nature and environmental impact (Chaudhary et al., 2024). The use of plant natural product-based insecticides, including those derived from duku peel, constitutes an alternative to chemical insecticides as they are degraded more easily and are less harmful to the environment, with lower toxicity to non-target insects (Silvério, Espindola, et al., 2020). This environmental advantage is particularly relevant when considering pyrethroid resistance in vector populations, as essential oils and plant extracts have been explored to identify repellent molecules effective against resistant insect populations (Gnankiné & Bassolé, 2017).

The development of duku peel extract as an insecticidal agent offers significant environmental and health benefits compared to synthetic pyrethroid insecticides. The use of biological insecticides derived from *Lansium domesticum* represents an alternative approach to overcome limitations associated with conventional chemical pesticides (Putri et al., 2024). The peel extract of *Lansium domesticum* can be utilized as a bioinsecticide providing an environmentally friendly option for pest control applications. The traditional use of duku in Southeast Asian folk medicine for treating insect bites and as a mosquito repellent Abdallah et al. (2022) provides ethnobotanical support for its insecticidal properties and suggests a long history of safe use in human populations. This traditional knowledge base, combined with modern phytochemical analysis and bioassay validation, supports the development of duku peel-based insecticides as safer alternatives to synthetic pyrethroids (Abdallah et al., 2022; Deliza et al., 2025).

While duku peel demonstrates promising insecticidal activity, several challenges remain in its development as a practical pyrethroid alternative. Essential oils and plant extracts generally

exhibit drawbacks due to their high volatility and low aqueous solubility, which may limit their field application and persistence. Current stabilization techniques, such as nanoencapsulation, are being explored to prolong the efficacy of plant-based bioinsecticides, and similar approaches may enhance the practical utility of duku peel extracts (Garrido-Miranda et al., 2022). Future research should focus on comprehensive field studies evaluating the long-term effectiveness and practical application of duku peel extracts in diverse agricultural and public health settings. Additionally, detailed chemical characterization of the specific compounds responsible for pyrethroid-like activity, combined with mechanistic studies elucidating their modes of action on target arthropod nervous systems, would strengthen the scientific basis for duku peel development as a pyrethroid alternative.

4. CONCLUSION

This community service program successfully transformed the perception of duku peel from worthless agricultural waste into a high-value, marketable product, effectively addressing the dual challenges of environmental waste and the need for economic diversification in Talang Duku Village. The empowerment initiative significantly enhanced the 'A. Khalik duku plantation' Farmers Group's capacity, fostering a new class of "creative healthpreneurs" by equipping them with the knowledge and practical skills to produce plant-based insecticide in the form of aromatherapy candles. The program's impact is evidenced by a significant increase in the participants' understanding and technical abilities, the successful creation of a product well-received by the community for its dual efficacy and therapeutic aroma, and the establishment of the 'KUB Duku Lestari' Joint Business Group. The formation of this business entity and its initial sales success mark the beginning of a sustainable and independent entrepreneurial ecosystem, providing a direct positive economic impact and improving the community's welfare.

The implications of this program extend beyond local economic benefits, offering a replicable model for sustainable rural development that integrates scientific innovation with community empowerment. For future development, it is recommended that 'KUB Duku Lestari' focuses on standardizing packaging to increase market appeal and explores broader market access through official retail and digital channels. Further research to optimize extraction techniques and analyze the chemical composition of the duku peel extract could also enhance product efficacy and open opportunities for product diversification.

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest in the publication of this article.

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