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Local Specialty Product Innovation of Tilapia Fish Nugget "Spirunila" through the Empowerment of Karangtaruna Pemuda Mudi Gabahan (PMG) and Persons with Disabilities in Mulur Village

Agung Setyarini[1], Sari Widati[2], Salsabila Amalia Putri Bumi[3], Fandi Galang Wicaksana[4], Sangga Rizki Ramadhan[5], Annisa Nur Safitri[6]
[1] Faculty of Agriculture, Bangun Nusantara University
[2] Faculty of Economy, Bangun Nusantara University
[3] Faculty of Food and Healthy Science, Sugeng Hartono University
[4] Faculty of Economy, Tidar University
[5] Faculty of Agriculture, Bangun Nusantara University
[6] Faculty of Economy, Bangun Nusantara University
[1] setyoriniagung16@gmail.com
[2] sariwidati@gmail.com
[3] salsabilaapb@gmail.com
[4] fandi@untidar.ac.id
[5] sanggarramadhan@gmail.com
[6] annisasafitri@gmail.com

Abstract
This community service program responds to the underutilization of tilapia production in Mulur Village, Sukoharjo, where limited product diversification constrains economic growth. The program introduced Spirunila, a fortified tilapia-based product, while empowering the PMG Youth Organization and persons with disabilities through an Inclusive Joint Business Group (KUBA). The Participatory Learning System (PALS) was implemented to deliver capacity-building activities in production technology, entrepreneurship, and digital marketing. Program effectiveness was evaluated using pre- and post-test questionnaires on seven indicators, which were analyzed using a Paired Sample t-Test, N-Gain Score, and Cohen's d. The results showed statistically significant improvements ($p < 0.001$), high learning gains (N-Gain category: High), and substantial effect sizes ($d > 1.97$), demonstrating strong behavioral and capability transformation among partners. Institutional strengthening ensures sustainability through shared production governance and digital market expansion. The findings confirm that inclusive innovation in community-based fish processing can enhance rural economic diversification and reinforce village tourism competitiveness.

Keywords: *Community Empowerment; Food Security, Local Product Innovation, Tilapia Fish Nugget*

Introduction

Mulur Village, Bendosari District, Sukoharjo Regency, located 5.6 km from Bangun Nusantara University, Sukoharjo, spans an area of 401 km² and holds strategic potential in the fisheries sector. This potential is further enhanced by the Mulur Reservoir, a water infrastructure that serves as the main center for fish farming using a cage system, producing commodities such as tilapia, gourami, catfish, and patin. This reservoir not only supports fisheries activities in Mulur Village but also provides a livelihood for 8,016 people. Mulur Village's demographic structure is dominated by farmers, who constitute 48.12% of the total population. Additionally, 34.16% of residents work as civil servants (ASN/TNI/Polri), while another 17.72% are students (BPS Kabupaten Sukoharjo, 2023).

Data from the Sukoharjo Regency Agriculture and Fisheries Office in 2023 recorded fish production from the Mulur Reservoir in Bendosari District reaching 1,066.17 tons (Table 1), reflecting significant economic potential for the Mulur Village community. However, the absence of Joint Business Groups (KUBA) and the limited diversification of processed fishery products limit the community's opportunities to earn additional income, necessitating strategic efforts to strengthen the local economy and food security.

Table 1. Aquaculture Production in Sukoharjo Regency in 2023

No	Subdistrict	Pool Catch	Fish Cage Catch	*Sawah (Minapadi)*	Amount
1	Weru	653,13	0,00	0,00	653,13
2	Bulu	662,59	0,00	0,00	662,59
3	Tawangsari	857,25	348,89	0,00	1.206,14
4	Sukoharjo	1.346,58	145,86	0,00	1.492,43
5	Nguter	1.427,22	0,00	0,00	1.427,22
6	Bendosari	807,79	1.066,17	0,00	1.873,96
7	Polokarto	1.371,71	0,00	0,00	1.371,71
8	Mojolaban	1.003,12	2,88	0,00	1.006,01
9	Grogol	1.224,71	652,20	0,00	1.876,92
10	Baki	1.013,80	0,00	0,00	1.013,80
11	Gatak	983,73	0,00	0,00	983,73
12	Kartasura	1.223,63	0,00	0,00	1.223,63
	Amount	**12.575,26**	**2.216,01**	**0,00**	**14.791,26**

Source: (BPS Kabupaten Sukoharjo, 2023)

The high production volume of cage fish farming, particularly tilapia, has not been matched by an adaptive marketing system, resulting in low profit

margins (Figure 1). This imbalance between production volume and economic value reflects stagnation due to limited support systems and inadequate resources (Jasmianto et al., 2021). Access to capital also hampers the adoption of modern technology needed for production efficiency (Sukajie et al., 2023). Furthermore, minimal promotion also limits consumer understanding of locally processed fish-based products. Product innovation based on local wisdom and an adaptive marketing approach are strategic imperatives for KUBA Mulur Village to strengthen its competitiveness and expand its market reach (Rizkaprilisa et al., 2023; Usman et al., 2024).

On the other hand, Sukoharjo Regency recorded a relatively high prevalence of people with disabilities, with Bendosari District significantly affected by 337 people (8.82 percent), including 41 people with hearing/speech disabilities residing in Mulur Village (Dinas Kependudukan dan Pencatatan Sipil Kabupaten Sukoharjo, 2024). In response to this issue, the Sukoharjo Regency Government has enacted supporting regulations, namely Peraturan Daerah Kabupaten Sukoharjo Nomor 18 Tahun 2017 Tentang Penyandang Disabilitas dan Peraturan Bupati Kabupaten Sukoharjo No. 3/2019 concerning Petunjuk Pelaksanaan Peraturan Daerah Kabupaten Sukoharjo No. 18/2017 concerning Persons with Disabilities to promote independence for individuals with disabilities through empowerment based on individual potential. Based on the official classification, disabilities include physical, blind, deaf/mute, mental, and a combination of physical and mental (Dinas Kependudukan dan Pencatatan Sipil Kabupaten Sukoharjo, 2024). Undang-Undang No. 8/2016 concerning Persons with Disabilities, as well as derivative policies of Peraturan Pemerintah No. 70/2019 concerning Planning, Implementation, and Evaluation of Respect, Protection, and Fulfillment of the Rights of Persons with Disabilities, and Peraturan Menteri Ketenagakerjaan No. 21/2020 concerning Guidelines for the Implementation of Disability Service Units in the Employment Sector, affirm the rights of persons with disabilities to appropriate employment. Its implementation requires cross-sector collaboration, including government, the business world, universities, and disability organizations.

Figure 1. Potential and Marketing of Fish Products (Shinta, 2023)

In an effort to empower the community, the Community Service Program, initiated by PKM from Veteran Bangun Nusantara University Sukoharjo (Univet Sukoharjo), has launched a program in Mulur Village, Bendosari District, in response to the needs of its partner, KUBA. KUBA serves as a collaborative platform between the PMG Youth Organization (Karangtaruna PMG) and individuals with hearing and speech disabilities, aiming to increase income and social welfare by processing economically valuable fish products based on local wisdom. The PMG Youth Organization, consisting of 15 youth from Gabahan Hamlet, currently actively manages the Mulur Reservoir Tourism Village, integrated with surrounding MSMEs. However, the destination's economic potential is less than optimal due to the activity being only busy on weekends. The lack of productive activities on weekdays, limited product innovation, and weak managerial and digital marketing capacity are the main challenges to the sustainable development of Mulur Reservoir tourism. People with hearing and speech disabilities are based on their productive capacity (generally having intact physical functions) without significant obstacles, and are suited to production and marketing activities. This *PKM* program involved strategic stakeholders, including SEHATI Sukoharjo, a social organization focused on empowering people with disabilities through training, mentoring, and sign language-based communication, and the Sukoharjo Regency Health Office, which played a role in food safety testing and product nutritional analysis. The situation analysis revealed three main problems: (1) the absence of KUBA (a food processing facility) that integrates people with disabilities, coupled with low innovation in processing fish into value-added products; (2) limited access to capital that hinders the adoption of production technology; and (3) non-adaptive marketing strategies that hinder the optimization of business profitability.

As a key innovation, the *PKM* Team, along with partners, developed a local specialty product, "Tilapia Fish Nuggets Fortified with Spirulina and Omega-3," named "Spirunila." This innovation is based on various scientific studies demonstrating that spirulina significantly contributes to increasing the nutritional value of food. Numerous studies have demonstrated the potential of spirulina as a functional ingredient in various food products, including extruded foods and health supplements. Spirulina, a type of blue-green microalgae, is increasingly recognized as a sustainable, environmentally friendly, and nutrient-rich food source that is being integrated into various food products (Armelia et al., 2023). The Indonesian Agency for Research and Innovation (BRIN) also utilizes spirulina as a food source in Indonesia (Simanjutak, 2022). Spirulina has significant potential to address future global health and nutrition challenges, including improving heart health, strengthening the immune system, and potentially having anticancer effects (Bortolini et al., 2022). *PKM* follows up on findings from similar *PKM* on the use of spirulina fortification to improve product nutrition (Kusumaningtyas & Muflihah, 2022; Salam, 2017; Setyaningsih et al., 2015). Providing inclusive fish-based product processing skills to the PMG Youth Organization and people with disabilities, followed by the development of KUBA, is expected to increase innovation in the local specialty product "Spirunila."

This *PKM* program aimed to achieve several specific objectives, the outcomes of which are detailed in the results section. The primary goal was to increase the knowledge, motivation, and awareness of both the PMG Youth Organization and persons with disabilities regarding the economic potential of processing tilapia into innovative, value-added products. Concurrently, the program aimed to enhance partners' technical capacities by providing hands-on training in production skills and the mastery of production technologies, such as meat grinders, planetary mixers, and vacuum sealers, among others. A crucial objective was the institutionalization of this empowerment through the establishment of an inclusive KUBA. Furthermore, the program aimed to build partners' entrepreneurial mindsets and digital marketing skills, covering branding, packaging, and the use of social media and e-commerce, thereby strengthening their overall capacity for sustainable business.

Method

The implementation method of community service activities adopts the Participatory Learning System (PALS) approach (Mayoux, 1998). This method is considered most appropriate because the program focuses on inclusive empowerment and long-term sustainability, which cannot be achieved with one-way training alone. Unlike top-down instructional methods, PALS actively involves both partner groups, the PMG Youth Organization and people with disabilities, at every stage. This approach ensures that the skills transfer process, such as production and marketing technology, is delivered inclusively, including through sign language support. The stages of all activities for the Innovation of Local Typical Products of Tilapia Fish Nuggets "Spirunila" through the Empowerment of Karangtaruna PMG and People with Disabilities in Mulur Village in 2025 are as follows:

1. Awareness

The activity began with an awareness-raising phase aimed at building collective awareness of the economic potential of tilapia cultivation and the strategic role of the PMG Youth Organization and Persons with Disabilities through collaboration with SEHATI Sukoharjo partners (intensively assisting Persons with Disabilities). Outreach was carried out through cross-stakeholder coordination and strengthening commitment to the establishment of the "Spirunila" KUBA. Activities included:

a) Socialization of the potential of fishery processing businesses, including developing plans for outreach and training activities, scheduling, locations, times, and event schedules;
b) Introducing the innovative local product "Spirunila" to partners;
c) Building a shared commitment to actively and inclusively involve vulnerable groups, especially persons with disabilities.
d) Purchasing equipment and materials. This activity was conducted to meet the needs for use during the training sessions.

2. Capacity Building

The capacity building phase aims to improve partner skills through technical training that addresses limitations in production, technology utilization, and marketing, which are still not yet adaptive to current

developments. The material is delivered inclusively through a combination of lectures, hands-on practice, and sign language support. Activities include:

a) Introduction to production and packaging equipment, including meat grinders, planetary mixers, nugget molds, steamers, vacuum sealers, and nugget storage refrigerators (freezers).
b) Training on Spirunilla product processing, from ingredient preparation to storage (freezers);
c) Use of Spirunilla product production and packaging equipment;
d) Providing material on the importance of trademarks and logo/packaging design (branding), as well as digital marketing techniques through social media and e-commerce.

3. Mentoring

During the mentoring phase, the *PKM* team focuses on directly implementing training outcomes through structured practice. This phase focuses on enhancing product quality and strengthening digital marketing through inclusive branding and content strategies. Activities include:

a) Packaging design and digital marketing to reflect local identity and visual marketing strategies on digital platforms;
b) Management of social media and marketplace accounts as a strategy for expanding market reach.

4. Institutionalization

The institutionalization phase consolidates the formal institutional framework of KUBA Inclusive. This phase ensures the sustainability of the program through a simple, digital-based business management system. Activities include:

a) Establishing the KUBA Inclusive structure by involving partners fairly and equally;
b) Production and financial management training to improve partners' managerial skills in managing production schedules, managing raw materials, and ensuring food product sanitation.

5. Program Evaluation and Sustainability

Periodic evaluations to assess program effectiveness are conducted through pre- and post-test checklists. Sustainability is ensured through intensive post-project mentoring by the proposing team. Activities include:

a) Program Evaluation

The program evaluation was conducted to assess the effectiveness of activities in improving partners' knowledge, skills, and independence. A quantitative methods approach was applied (pre-test and post-test). The evaluation instrument consisted of a questionnaire measuring seven key indicators: (1) knowledge; (2) motivation; (3) capability of production technology; (4) production skills; (5) entrepreneurship; (6) empowerment and inclusivity; and (7) digital marketing.

Data were analyzed using a paired sample t-test (Kim, 2015) to measure statistical significance, Cohen's d (Lakens, 2013) to determine effect size, and the Normalized Gain Score (N-Gain) (Hake, 1998) to assess improvement magnitude.

$$\mathrm{N-Gain} = \frac{Post\ test - Pre\ test}{Maximum\ Score - Pre\ test}\, x\ 100\%$$

The N-Gain results indicate the magnitude of the average improvement and are used to assess the program's level of success.

b) Program Sustainability.

Program sustainability was ensured through the institutionalization of the Inclusive KUBA structure and continuous mentoring by the implementation team after the project's completion. The sustainability strategy comprises three main components:

- Monitoring and Management, conducted periodically to assess improvements in production capacity, business management independence, and the application of inclusive principles within group activities.

- Institutional Strengthening, organizational development of KUBA to enable independent operation and maintain economic activities after the program ends.
- Digital Network Strengthening, utilizing social media and e-commerce platforms to expand product marketing beyond Mulur Village.

Result

This community service activity was conducted for Mulur Village partners through the socialization of the Spirunila product innovation program, including pre-production, post-production, and marketing strategies for Spirunila products. The collaboration between Universitas Veteran Bangun Nusantara and Universitas Sugeng Hartono, the PMG Youth Organization, and people with disabilities began with the socialization of the local specialty product innovation program, "Spirunila," to build awareness, understanding, and commitment to partner participation. The existing potential of tilapia fish resources has not been fully utilized due to a lack of awareness and understanding among partners regarding the production of value-added processed products. This limitation is reflected in the lack of technical knowledge about food processing, the limited experience in utilizing appropriate technology, and a low entrepreneurial orientation. Partners tend to view the potential of tilapia as limited to household consumption sold in raw form, without any initiative to diversify the product. Thus, awareness of the strategic value of the Spirunila nugget innovation is still limited. After the socialization, the partners' collective dedication to commitment increased, followed by technical skills and levels of critical awareness. Additionally, fresh tilapia fish from Mulur Village fish farmers are carefully selected according to the standards for processing into nuggets. This is followed by the fish cleaning process, which involves removing scales, gills, and internal organs. This process emphasizes the cleanliness and sanitation of products. The importance of this process is emphasized to ensure the product meets consumer expectations.

Figure 2. Sipurnila Product Innovation Socialization with PNG Youth Organization and People with Disabilities

Spirunila production training is the next stage of the program. This activity begins with an introduction and application of production technology that meets food safety standards. Partners are trained to operate various pieces of equipment, including meat grinders, planetary mixers, steamers, and vacuum sealers, providing them with practical experience in producing products of consistent and hygienic quality. To strengthen sustainability, production training is not only targeted individually but also facilitated through the formation of Spirunila's KUBA. KUBA was established to foster collaboration between the PMG Youth Organization and people with disabilities, promoting inclusive roles and opportunities. Next, an introduction to product design and branding is conducted. Partners are encouraged to understand that product quality is determined not only by taste and nutritional value, but also by the appearance of the packaging and brand image. Spirunila's packaging design considers aesthetic aspects, local identity, and market appeal. In addition, branding is used to strengthen the position of Mulur Village's culinary icon among similar products.

Figure 3. Introduction to Spirulina Technology and Production Process by PMG Youth Organization and Persons with Disabilities

The *PKM* Univet Sukoharjo team initiated the Spirunila production process by outlining the stages of raw material preparation, production, and packaging. The first stage requires ±10 medium-sized garlic cloves, ½ medium-sized onion, 5 tablespoons of cornstarch, 10 tablespoons of flour, 1 carrot, salt, 2 teaspoons of pepper, ½ teaspoon of nutmeg, 2 teaspoons of spirulina powder, 2 chicken eggs, ±2 cups of breadcrumbs, and cleaned tilapia fish meat. The second stage involves grinding 1 kg of fresh tilapia fish meat using a meat grinder for approximately 5 minutes to prepare the spices and spirulina powder as fortification ingredients. The PMG Youth Organization was involved in the gradual mixing process, which involved using a planetary mixer for 5 minutes. This process combined the ground meat with the order of raw materials, including finely chopped onions, flour, carrots, spices, and spirulina, until a homogeneous mixture was achieved. At the same time, people with disabilities operated an automatic steamer to steam the dough for approximately 50 minutes at 100°C. Partners were given an understanding that steaming is necessary to ensure the dough is cooked evenly, kill harmful microorganisms, and increase the dough's binding strength. After steaming, the dough temperature was lowered to approximately 27°C for 15 minutes, then cooled at 0-4°C for approximately 30 minutes. This cooling stage is crucial for maintaining the dough's texture before entering the molding process. The next stage involved partners molding the dough with a nugget molding tool, using a standard size of 25-30 grams per piece. They then proceeded to coat the dough with egg (buttering) and continued with breadcrumbs (breading) until the coating was evenly distributed. This coating aims to form a crispy outer layer after frying, while also adding flavor.

In the final stage of the training, the *PKM* Team and SEHATI Sukoharjo directly assisted with the short baking process, which lasted approximately 10 minutes at a temperature of 180 °C. This was followed by freezing in a freezer at a temperature of -18 °C to -25 °C for a minimum of 4 hours. The freezing stage aims to extend the product's shelf life to 3 months without the use of preservatives. Next, a frying trial is conducted, followed by packaging. Persons with disabilities were accompanied by SEHATI Sukoharjo, who operated a vacuum sealer to extract air from the packaging process, with each package containing six pieces. The active collaboration between the *PKM* team, SEHATI Sukoharjo, PMG Youth Organization, and persons with disabilities not only produced hygienic, nutritious, and ready-to-eat Spirunila products, but also developed new technical skills and built self-confidence in togetherness. Through direct experience in production, partners discovered that local tilapia has the potential to be processed into innovative products that hold economic value while strengthening the identity of Mulur Village.

Figure 4. Spirulina Packaging by PMG Youth Organization and Persons with Disabilities

After going through the three stages above, the training session concluded with partners involved in production and packaging tasting the products to ensure quality and taste met the established standards. Partners responded enthusiastically to the training, gaining new skills through fish processing that had not been previously practiced. Fellow individuals in KUBA were able to exchange ideas and provide input in developing innovations in both product texture and taste. Through this practical training approach and dedicated mentoring, the PMG Youth Organization and

individuals with disabilities were able to increase their production capacity, utilize technology more effectively, and market their products more adaptively and competitively. Thus, the training and mentoring had a clear socio-economic impact on partners. There was a significant difference in conditions before and after the program was implemented, from previously selling raw tilapia and processing it on a general basis, to partners discovering new business opportunities that provide added value, especially in processed tilapia products. Spirunila products can significantly enhance partners' managerial understanding and technical skills, while facilitating increased income through inclusivity. This program plays a vital role in supporting the local economy by proposing innovations in local village products and promoting tourism destinations based on fish farming and culinary areas. KUBA's main challenge going forward is expanding its technology-based marketing network, including digital platforms such as social media/e-commerce and consignment in contemporary stores, to ensure business sustainability.

The results of the *PKM*, including the Spirunila product innovation involving the PMG Youth Organization and groups of people with disabilities in Mulur Village, are presented based on three main activity stages: socialization, pre-production, and post-production. Each stage was evaluated using a Likert-scale questionnaire (1–4) administered before and after the program intervention. To rigorously analyze the evaluation data, three complementary analytical techniques were applied. First, the Paired Sample T-Test refer to (Kim, 2015) was employed to statistically estimate whether the observed changes in participants' scores between pre-test and post-test were significant. Second, the magnitude of improvement in partners' capacity was quantified using the N-Gain Score by (Hake, 1998), which indicates the proportion of the maximum possible improvement achieved throughout the intervention. Third, Cohen's d effect size reviewed by (Lakens, 2013) was computed to assess the practical significance and strength of the program's impact beyond statistical findings. These analytical approaches were jointly used to assess improvements across seven key indicators: knowledge, motivation, capability of production technology, production skills, entrepreneurship, empowerment and inclusivity, and digital marketing. The combined results provide a comprehensive overview of initial conditions, transformative outcomes, and strengthened partner engagement, confirming

the program's contribution to enhancing inclusivity and sustainability within the community.

The pre-test and post-test questionnaire evaluation results (Table 2) show significant improvements in all seven key indicators.

Table 2. Pre-Post Statistical Evaluation Results

No	Evaluate	n	Mean of Pre-test	Mean of Post-test	t(df)	p-value	N-Gain (%)	Category	Cohen's d	Interpretation
1	Knowledge	20	46.40	90	14.1	< 0.001	93.97	High	2.39	Substantial effect
2	Motivation	18	49.80	94.40	13.75	< 0.001	89.56	High	2.44	Substantial effect
3	The capability of production technology	18	41.20	89.80	15.84	< 0.001	117.96	High	2.85	Substantial effect
4	Production skills	18	43	84.80	11.96	< 0.001	97.21	High	2.17	Substantial effect
5	Entrepreneurship	18	49.40	86.80	10.72	< 0.001	75.71	High	1.97	Substantial effect
6	Empowerment and inclusivity	18	44.20	89.80	15.20	< 0.001	103.17	High	2.78	Substantial effect
7	Digital marketing	18	47.60	91.40	13.41	< 0.001	92.02	High	2.37	Substantial effect

Source: Data processed by researchers

The statistical analysis results presented in Table 2 indicate a highly significant increase in partner capacities across all seven evaluation indicators. Statistically, the paired t-test results show p-values < 0.001 for all indicators, confirming that the program has a scientifically significant effect on the assessed parameters.

In addition, the N-Gain Score, which falls into the High category for all indicators, demonstrates the strong instructional effectiveness of the intervention in improving participants' capacities from relatively low initial conditions. The highest improvement was found in the capability of production technology (117.96%), followed by empowerment and inclusivity (103.17%) and knowledge (93.97%), highlighting the success of the technological empowerment approach in food production and inclusive community engagement.

Furthermore, Cohen's d effect size results show values exceeding 2.0 across all indicators, which are academically classified as substantial effects. This reinforces that the program not only produces statistically significant outcomes but also demonstrates a powerful practical impact in transforming participants' behavior, skills, and entrepreneurial orientation.

Overall, the combined evidence from the paired t-test, N-Gain Score, and effect size strongly supports the conclusion that the community empowerment program has effectively enhanced production capabilities, entrepreneurial readiness, and digital literacy among members of the PMG Youth Organization and people with disabilities, ensuring the sustainability of the Spirunila product innovation initiative.

Discussion

The significant improvement in knowledge and motivation reflects partners' ability to internalize the social and economic value of the Spirunila innovation through participatory learning. The PALS approach, which emphasizes problem-solving and reflective engagement, has been proven to enhance cognitive understanding and promote adaptive behavior in rural community empowerment initiatives (Kusumaningtyas & Muflihah, 2022; Mayoux, 1998). The structured awareness activities can transform community perceptions from a subsistence orientation to one of value-added production. Motivation increased not only due to the training design but also because participants recognized Spirunila as an economically profitable product, which encouraged entrepreneurial aspirations similar to those found in other community-based fish processing programs in Malang and Makassar (Armelia et al., 2023).

Improvements in technology mastery and production skills confirm the effectiveness of inclusive, hands-on training in accelerating skill acquisition and supporting the adoption of technology. These findings align with previous studies, which highlight that modern processing equipment, when accompanied by hygiene and food safety standards, optimizes efficiency and product quality, enabling small producers to meet market demands (Bortolini et al., 2022). The disability-inclusive approach further enhanced learning accessibility and production consistency, supporting national guidelines on inclusive vocational training (Peraturan Menteri Ketenagakerjaan No. 21/2020; PP No. 70/2019). These outcomes reveal that

partners are now equipped not only to operate technology but also to maintain consistent production quality, a core requirement for micro-enterprise competitiveness.

The increase in entrepreneurship and digital marketing literacy demonstrates a shift from production-oriented behavior to market-driven decision-making. Digital platform utilization has expanded market access and reduced dependency on weekend-based tourism, consistent with evidence that online commercialization enhances business resilience for rural MSMEs (Sukajie et al., 2023; Usman et al., 2024). Enhanced creativity in branding and proactive customer engagement indicate participants' readiness to operate competitively in the culinary innovation sector (Rizkaprilisa et al., 2023). This shift from product-centered to market-oriented behavior marks a meaningful entrepreneurial transformation among partners.

Meanwhile, improved empowerment and inclusivity outcomes demonstrate the strategic value of integrating people with disabilities into local business ecosystems. Inclusive enterprise models such as KUBA strengthen collective identity, enhance productivity, and dismantle social stigma through shared responsibilities and decision-making (Undang-Undang No. 8/2016; Peraturan Daerah Kabupaten Sukoharjo No. 18/2017). Similar evidence from empowerment programs confirms that when persons with disabilities are engaged in leadership roles, self-efficacy and mutual respect increase across the group (Salam, 2017). This reflects broader empirical evidence that when individuals with disabilities gain economic roles, social cohesion and group performance also improve. Thus, the partnership between PMG Youth Organization and individuals with disabilities becomes a strategic driver of both equality and economic resilience.

Reflectively, the establishment of KUBA as an inclusive institutional structure ensures post-program continuity through shared governance, market legitimacy, and coordinated resource management. Cooperative institutionalization has been widely recognized as a crucial factor in sustaining rural SMEs, enabling long-term survival and stronger entrepreneurial ecosystems (Jasmianto et al., 2021). Thus, the program provides a replicable community empowerment model for rural tourism-based economies.

Overall, the convergence of statistically significant results ($p < 0.001$), high learning gains, and substantial effect sizes ($d > 1.97$) demonstrates

meaningful behavioral transformation and commercial readiness among participants. The novelty of this program lies in its integration of fish-based food fortification, disability-inclusive entrepreneurship, and digital market expansion, creating a scalable pathway to strengthen rural food security and enhance village tourism competitiveness (BPS Kabupaten Sukoharjo, 2023).

Conclusion and Suggestion

The Community Service Program (*PKM*) program, which utilizes Spirunila's innovation— a spirulina- and omega-3-fortified tilapia nugget — has proven to have a significant impact on increasing the capacity of partners, namely the PMG Youth Organization and groups of people with disabilities in Mulur Village. Evaluation results showed a significant increase in scores across all indicators, from knowledge, motivation, mastery of production technology, production skills, entrepreneurship, inclusive empowerment, to digital marketing, as indicated by statistically significant improvements ($p < 0.001$), high learning gains, and substantial effect sizes ($d > 1.97$). The highest increase was for the capability of production technology, with an N-Gain of 117.96% and Cohen's d of 2.85. This increase confirms the effectiveness of the PALS method used in building awareness, strengthening technical skills, and fostering a commitment to inclusive entrepreneurship, addressing the partner gaps identified during the pre-test.

This *PKM* program was developed through a participatory and inclusive collaboration, involving SEHATI Sukoharjo as a mentor for people with disabilities to ensure program sustainability. Future programs are expected to focus on intensive KUBA mentoring to increase capacity in product innovation, more efficient production management, strengthening digital-based marketing strategies, and simplifying bookkeeping. Furthermore, the most important factor driving the importance of legal compliance includes nutritional testing in accordance with laws and regulations on food and consumer safety, as well as distribution permits through the issuance of a Business Identification Number (*NIB*), a Home Industry Food Certificate (*PIRT*), and/or halal certification. This is done to ensure the product's commercial viability and consumer safety requirements. Therefore, the long-term participation of Mulur Village stakeholders is expected to strengthen Spirunila's value-added economic business, achieving increased independence and food security for local products.

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