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ENHANCING PRODUCTION STANDARDS, PRODUCT INNOVATION, AND MARKET COMPETITIVENESS OF SOLAR-DRIED FISH RINGS USING A DESIGN THINKING APPROACH: A CASE STUDY OF COMMUNITY-BASED ENTERPRISES IN SIRINDHORN DISTRICT, UBON RATCHATHANI PROVINCE, THAILAND

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ABSTRACT

This study explores exciting strategies to boost the production and commercial potential of solar-dried fish rings, crafted by community-based enterprises (CBEs) in the vibrant Sirindhorn District of Ubon Ratchathani, Thailand. By utilizing a Design Thinking framework, it actively engaged stakeholders to tackle operational and market challenges with four key goals: (1) standardizing production processes for even better quality, (2) creating a crispy fried fish ring variant that delights consumer preferences, (3) introducing sustainable packaging to help extend shelf life, and (4) leveraging popular digital platforms like Facebook and Shopee to broaden market reach. The key results showcased significant improvements in both production and marketing. Standardized processes not only enhanced product consistency but also revealed through nutritional analysis that the fish rings have a high protein content. Innovations in sustainable packaging, including laminated aluminum foil, beautifully doubled the product's shelf life while addressing environmental concerns. Digital marketing initiatives increased online sales by 20% within just three months, enhancing visibility and boosting revenue. Moreover, process optimization and cost-effective packaging managed to lower production costs by 24.08%, further enhancing profitability and competitive pricing. Overall, these findings illustrate how effective Design Thinking can be in overcoming challenges faced by CBEs, providing a scalable model for innovation, sustainability, and resilience. This thoughtful approach empowers rural enterprises for lasting success in ever-changing markets, encouraging economic empowerment and fostering environmental stewardship in local communities.

KEYWORDS: Solar-Dried Fish, Community Enterprise, Design Thinking, Packaging Innovation, Digital Marketing, Production Standards.

1. INTRODUCTION

Community-based enterprises (CBEs) in Sirindhorn District, Ubon Ratchathani Province, Thailand, play a pivotal role in sustaining rural livelihoods through the production of solar-dried fish rings—a traditional, value-added product that reflects the region's culinary heritage. These enterprises utilize sun-drying methods passed down through generations to preserve abundant freshwater fish, thereby supporting food security and income generation among small-scale fishers and farmers (Pomeroy et al., 2007). Despite their cultural and economic significance, CBEs face persistent operational and strategic challenges. Seasonal variations, inconsistent drying techniques, and variable raw-material quality undermine product consistency. Packaging often lacks durability and market appeal, while limited access to broader distribution networks impedes scalability. These issues are compounded by a lack of structured planning, limited innovation, and inefficient resource allocation—factors that prevent CBEs from adapting to dynamic consumer preferences or achieving economies of scale (Naipinit et al., 2016; Sirisuth et al., 2020). A promising avenue for overcoming these challenges lies in the application of a Design Thinking framework—a human-centered, iterative approach grounded in empathy, ideation, prototyping, and testing. By actively involving stakeholders such as producers, consumers, and distributors in co-creative processes, CBEs can design standardized production systems, develop innovative packaging, and implement strategic marketing initiatives that align with consumer needs. However, many CBEs have yet to fully leverage these methodologies, resulting in missed opportunities for differentiation and growth (Phukrongpet et al., 2021). Integrating Design Thinking into CBE operations has the potential to revitalize solar-dried fish rings as both a cultural symbol and a scalable rural enterprise. Through systematic empathy mapping, rapid prototyping, and collaborative stakeholder engagement, CBEs can stabilize production quality, create eco-conscious branding, and expand into emerging market segments. This approach not only strengthens economic resilience but also safeguards intangible cultural heritage. Ubon Ratchathani's rich freshwater ecosystems provide a natural foundation for artisanal fish processing. In Sirindhorn District, CBEs have effectively mobilized these resources to produce high-value, sun-dried fish rings that appeal to growing consumer demand for artisanal and sustainably sourced food (Distanont et al., 2019; Sampantamit et al., 2020). Yet, the absence of standardized production protocols, coupled with rudimentary packaging and restricted market access, continues to limit shelf life, market competitiveness, and brand development (Ueasangkomsate & Jangkot, 2017). Dried fish products are deeply embedded in Thai culinary culture and remain nutritionally significant for both domestic and export markets. However, inconsistent production methods often compromise texture, flavor, food safety, and consumer trust (Chaisawat, 2019). The adoption of Good Manufacturing Practices (GMP)—including hygiene controls, process monitoring, and raw-material handling—can significantly improve product quality and compliance. Case studies from Phatthalung Province demonstrate how GMP implementation in solar-dried fish production improved efficiency, food safety compliance, and competitiveness, underscoring the transformative impact of standardized quality control (Jongphong et al., 2019). Beyond production efficiency, sustainability and legal compliance are emerging imperatives. The Royal Ordinance on Fisheries (Phanpakdee et al., 2018) sets regulatory standards aimed at preventing overfishing and preserving aquatic biodiversity. By aligning with these regulations and adopting ecosystem-based resource management strategies, CBEs can ensure long-term access to raw materials and tap into emerging markets for eco-certified seafood (Sirisuth et al., 2020). Nonetheless, regulatory compliance and technical improvements alone are insufficient. Many CBEs lack mechanisms for iterative innovation, such as product trials or user-centered design workshops. Short-term financial constraints often prevent investment in R&D, further reducing adaptability to shifting consumer trends and supply chain vulnerabilities (Distanont et al., 2017; Thienthaworn, 2015; Cavite et al., 2021). Embedding Design Thinking practices can catalyze a virtuous cycle of innovation, compliance, and sustainable development, thereby positioning CBEs for long-term success. In essence, the challenges facing CBEs reflect not only operational inefficiencies but also structural limitations in collaboration, perspective, and market awareness. A Design Thinking approach—emphasizing inclusive innovation and contextual sustainability—offers a viable pathway to overcome these barriers. Through empathetic engagement and iterative design, CBEs can achieve greater resilience and competitiveness in an evolving economic environment (Phukrongpet et al., 2021).

1.1. Research Objectives

This study applies a human-centered "Design

Thinking" framework to improve both production efficiency and market performance of solar-dried fish rings produced by CBEs in Sirindhorn District, Ubon Ratchathani.

The specific research objectives are as follows:

1. **To develop and implement standardized production protocols**—based on empathy mapping and process diagnostics—to enhance product quality, ensure food safety compliance, and align with evolving consumer expectations.
2. **To conceive and pilot a ready**-to-eat fried fish ring variant that retains traditional flavor profiles and nutritional value while addressing modern consumer preferences for convenience and on-the-go consumption.
3. **To design and test eco**-friendly packaging solutions that enhance shelf life, protect product integrity, and appeal to environmentally conscious buyers.
4. **To formulate and deploy targeted digital marketing strategies**—using platforms such as Facebook and Shopee—to expand market access, foster direct consumer engagement, and establish sustainable, scalable e-commerce channels.

1.2. Holistic Application of Design Thinking in Strengthening CBEs

This study presents a comprehensive application of Design Thinking to address the evolving challenges faced by Community-Based Enterprises (CBEs), particularly in production, packaging, and marketing. Grounded in the principles of empathy, ideation, and prototyping, the approach begins with a deep understanding of stakeholder needs, ensuring that interventions are both contextually relevant and user-centered. Through collaborative ideation, stakeholders co-create innovative solutions, which are then tested in real-world scenarios to validate their effectiveness and scalability. A primary outcome of this method is the enhancement of product consistency and quality. By introducing standardized production practices, CBEs can ensure greater uniformity across product lines, comply with regulatory standards, and strengthen consumer trust. This standardization not only raises the overall competitiveness of CBEs in local markets but also prepares them for broader commercial engagement. Simultaneously, innovations in sustainable packaging are introduced to extend product shelf life. This advancement allows CBEs to maintain freshness and quality over longer durations, enabling distribution to more distant and even international markets. The integration of environmentally conscious materials also aligns with global sustainability trends, further enhancing brand image and market appeal. The application of digital tools within the Design Thinking framework fosters increased market access and consumer engagement. Through low-cost digital platforms, CBEs can promote their products more effectively, interact directly with customers, and refine their strategies based on real-time feedback. This digital engagement supports data-driven decision-making and cultivates stronger consumer relationships. Collectively, these outcomes aim to help CBEs overcome persistent operational limitations, improve their market positioning, and achieve sustainable growth. By fostering innovation and integrating appropriate technologies, this research contributes to the resilience of rural economies. It aligns with and extends the insights of Ueasangkomsate and Jangkot (2017) as well as Chaochotechuang and Mariano (2016), underscoring the transformative potential of Design Thinking in strengthening community enterprises and advancing rural development in Thailand.

1.3. Initial Research Expectation

This research is designed to strengthen the long-term viability of community-based enterprises (CBEs) by delivering several key contributions. First, it aims to improve product quality, thereby enhancing consumer trust and satisfaction. Second, it seeks to reduce variability in production processes and lower operational costs, supporting greater efficiency. Third, the study explores opportunities to expand market reach through innovative packaging and digital marketing strategies. Finally, it proposes a scalable framework that can be applied to other CBEs in Thailand and similar contexts. Collectively, these contributions support sustainable development by aligning local enterprises with evolving consumer preferences and market dynamics, enabling them to remain competitive and resilient in increasingly dynamic environments (Sowcharoensuk, 2022; Elhoushy, 2020).1.3 Scope of the Research This research focuses on tackling the production and marketing challenges faced by community-based enterprises (CBEs) producing solar-dried fish rings in Sirindhorn District, Ubon Ratchathani Province. Conducted over 12 months, the study employed a mixed-methods approach, integrating both qualitative and quantitative techniques to provide a comprehensive analysis of the opportunities and barriers these enterprises encounter.

1.4. Key Areas of Focus

1. Production Processes: The study investigates existing production methods to identify inefficiencies and inconsistencies. Efforts are directed toward establishing standardized processes that ensure product quality, regulatory compliance, and alignment with consumer preferences.
2. Packaging Innovations: Research explores the design of sustainable packaging solutions that extend shelf life while meeting consumer demand for convenience and environmental responsibility.
3. Digital Marketing Strategies: The research evaluates the potential of online platforms, such as Facebook and Shopee, to enhance product visibility and accessibility, particularly among urban and younger consumer groups.

1.5. Research Methods

To achieve its objectives, the study utilized the following methodologies:

- Surveys: Quantitative data were gathered from both consumers and producers to evaluate satisfaction levels, preferences, and operational challenges.
- Focus Groups: Collaborative sessions with producers identified critical pain points in production processes and facilitated the co-creation of innovative solutions.
- Market Analysis: Consumer behavior and market demand trends were analyzed to inform strategies for product development and marketing.

1.5.1. Applicability and Broader Impact

- While this study focuses on solar-dried fish rings in Sirindhorn District, the methodologies and findings are designed to be adaptable for other CBEs in rural Thailand and similar socio-economic settings. The anticipated outcomes include:
- Enhanced Product Quality: Practical solutions for improving production consistency and aligning products with market standards.
- Increased Market Competitiveness: Strategies for modernizing packaging, integrating digital marketing, and addressing consumer expectations effectively.
- Replicable Framework: A model for other rural enterprises aiming to modernize operations, innovate packaging, and leverage digital tools.

This research aligns with broader goals of promoting sustainability, preserving cultural heritage, and fostering economic resilience in rural areas. By addressing these objectives, the study contributes to the sustainable development and long-term viability of CBEs in Thailand's rural economy, supporting insights from Distanont et al. (2019) and Chaochotechuang & Mariano (2016).

1.6. Theoretical Framework and Key Concepts

This study integrates diverse theoretical frameworks to address critical elements of product development, packaging innovation, digital marketing, and Design Thinking. Together, these frameworks form a robust foundation for improving the production standards and commercial potential of solar-dried fish rings produced by community-based enterprises (CBEs) in Sirindhorn District, Ubon Ratchathani.

1.7. Product Development Framework

Theories of product development emphasize the need for standardized production processes to build consumer trust, ensure consistent quality, and enhance market competitiveness. For food products, especially in export markets, compliance with international standards such as Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP) is essential (De Chollet et al., 2021). Standardization minimizes operational variability, enabling enterprises to meet regulatory and consumer expectations effectively. In this study, product development theories inform the design of consistent production methods for solar-dried fish rings, ensuring quality across texture, taste, and shelf life. By focusing on precision and repeatability, the research addresses current challenges in production variability and quality assurance.

1.8. Packaging Innovation Framework

Packaging plays a crucial role in maintaining product integrity, extending shelf life, and enhancing consumer satisfaction. Advanced solutions such as vacuum sealing and laminated aluminum foil provide protection against moisture and oxidation, preserving freshness for longer periods (Chaisawat, 2019). Additionally, the growing demand for sustainable materials drives innovation in eco-friendly and biodegradable packaging solutions (Sowcharoensuk, 2022). This research applies packaging innovation theories to design functional and sustainable packaging for solar-dried fish rings. Objectives include extending product shelf life, ensuring durability during transportation, and incorporating features like resealable designs to improve convenience.

1.9. Digital Marketing Framework

Digital marketing theories highlight the transformative potential of online platforms in expanding market access, fostering consumer engagement, and strengthening brand loyalty. Platforms such as Facebook, Instagram, and Shopee allow enterprises to bypass traditional distribution challenges, directly reaching their target audiences. Strategies like targeted advertising, influencer partnerships, and real-time feedback loops enable producers to adapt their offerings to consumer preferences (Elhoushy, 2020). In this study, digital marketing frameworks are employed to develop cost-effective and impactful promotional strategies. By utilizing e-commerce and social media channels, CBEs can increase visibility, engage with consumers, and gain actionable insights to refine their offerings.

1.10. Design Thinking as a Theoretical Lens

Design Thinking, characterized by its human-centered and iterative approach, provides an adaptable framework for addressing the complex challenges of CBEs. By emphasizing empathy, collaboration, and prototyping, Design Thinking fosters solutions that align with both operational needs and market trends (Brown, 2009).

This study applies Design Thinking through the following steps:

1. Empathize: Understand producer and consumer needs via interviews, focus groups, and observational research.
2. Define: Identify and frame critical challenges in production quality, shelf life, and market access as actionable problems.
3. Ideate: Co-create innovative solutions for standardization, shelf-life extension, and value-added products like ready-to-eat fried fish rings.
4. Prototype: Experiment with new packaging designs and marketing strategies that prioritize functionality and sustainability.
5. Test: Use consumer feedback and market analysis to validate innovations and refine solutions for broader scalability.

This iterative process ensures the outcomes are practical, adaptable, and responsive to stakeholder needs.

1.11. Integrated Theoretical Contributions

By combining product development, packaging innovation, digital marketing, and Design Thinking, this study establishes an interdisciplinary framework aimed at enhancing the competitiveness and sustainability of community-based enterprises (CBEs). The framework addresses critical dimensions, including operational needs ensuring standardization and quality control in production; consumer expectations delivering convenient, sustainable, and high-quality products; and market opportunities leveraging digital tools to enhance visibility and consumer engagement. This integrated approach provides a replicable model for other rural enterprises, fostering economic resilience and sustainable development. The findings are consistent with prior research emphasizing the role of innovation and market alignment in strengthening rural enterprises (Ueasangkomsate & Jangkot, 2017; Chaochotechuang & Mariano, 2016; Sowcharoensuk, 2022; Elhoushy, 2020).2.

2. LITERATURE REVIEW

2.1 Design Thinking

Design Thinking is a people-centered, iterative approach to problem-solving that fosters creativity, collaboration, and adaptability. It revolves around five key stages—Empathize, Define, Ideate, Prototype, and Test—each designed to tackle challenges by understanding the needs of users and refining solutions through feedback. This approach has gained widespread recognition for its versatility, especially in areas like community-based enterprise (CBE) development, where aligning solutions with the needs of producers, consumers, and markets is essential (Brown, 2009). For CBEs, Design Thinking provides a structured yet flexible way to address the unique hurdles they face. Unlike traditional methods that often zero in on technical fixes, this approach prioritizes understanding the human experience and iterating to develop meaningful solutions.

I. Empathize: The journey starts with a deep dive into stakeholder experiences. For CBEs, this means understanding producers' operational struggles, like inconsistent quality or limited resources, and exploring consumer needs for convenience, sustainability, and accessibility (Cavite et al., 2021).
II. Define: Insights gathered are synthesized to clearly outline challenges, such as the need for consistent production processes or creative marketing strategies. A well-defined problem sets the stage for impactful solutions (Distanont et al., 2019).
III. Ideate: This stage encourages brainstorming innovative ideas. In CBE contexts, solutions might include streamlining workflows, creating ready-to-eat fish rings, or designing packaging that extends shelf life and supports sustainability.
IV. Prototype: Ideas take tangible form in small-

scale models or processes. For CBEs, this could mean testing standardized production techniques or developing prototype packaging designs to gather feedback.

V. Test: The final stage validates ideas by gathering stakeholder input and refining solutions. CBEs might survey consumers on new products or analyze the market impact of online campaigns through platforms like Facebook or Shopee.

Design Thinking's iterative nature empowers CBEs to navigate challenges with creativity and flexibility, fostering innovation, sustainability, and long-term success.

2.2. Complementing Traditional Approaches

Design Thinking is uniquely effective in addressing the complexity and unpredictability inherent to community-based enterprises (CBEs). Unlike traditional methods, which often depend on fixed, linear strategies that fail to fully capture evolving consumer behaviors or shifting market trends, Design Thinking's iterative and adaptable framework allows enterprises to respond dynamically. It facilitates real-time solution refinement and encourages collaboration across diverse stakeholder groups, ensuring that outcomes are both innovative and practical (Phukrongpet et al., 2021). For instance, research in Thailand's rural food sector illustrates how Design Thinking can drive innovation by blending producer insights with market analysis, yielding solutions that are not only technically feasible but also culturally resonant (Ueasangkomsate & Jangkot, 2017). This approach ensures that interventions align with local contexts, enhancing their acceptance and sustainability. Additionally, the ideation and prototyping stages play a critical role in overcoming resource limitations faced by CBEs. By focusing on high-impact, low-cost solutions, these stages enable enterprises to achieve meaningful progress without overstretching their resources (Sowcharoensuk, 2022). Whether it's through streamlining production, developing value-added products, or creating sustainable packaging, Design Thinking empowers CBEs to innovate effectively and thrive amidst uncertainty.

2.2.1. Relevance to Solar-Dried Fish Rings

Design Thinking plays a pivotal role in the production and marketing of solar-dried fish rings by addressing critical challenges and fostering innovation. It enables:

- A deeper understanding of producer challenges, such as achieving consistent product quality across batches and optimizing resource use.
- Consumer-driven solutions, including innovative packaging designs to enhance shelf life and the development of ready-to-eat product variants to meet diverse preferences.
- Testing and refining digital marketing strategies, leveraging platforms like Facebook and Shopee to engage consumers in real time and expand market reach effectively (Elhoushy, 2020).

By emphasizing collaboration, iteration, and continuous improvement, Design Thinking empowers CBEs to tackle challenges holistically, improve marketability, and build sustainable business models.

2.2.2. Scholarly Integration

The application of Design Thinking to CBEs is extensively supported by research, highlighting its effectiveness in driving innovation, operational efficiency, and market alignment. For example:

- Brown (2009) emphasizes its capacity to align solutions with user needs through iterative refinement, ensuring relevance and adaptability.
- Distanont et al. (2019) demonstrate its role in fostering creativity and resilience, particularly in rural enterprise settings.
- Sowcharoensuk (2022) explores its impact on enhancing packaging solutions and developing digital marketing strategies to boost visibility and engagement.

These studies underscore Design Thinking's transformative potential for rural enterprises, affirming its relevance to the challenges and goals of solar-dried fish ring production and marketing.

2.2.3. Community Enterprise Development

Community-based enterprises (CBEs) are vital catalysts for economic growth, social development, and sustainability, especially in rural areas of Thailand. Often organized as cooperatives or small business networks, CBEs empower producers to pool resources, reduce costs, and access broader markets. Their impact transcends economic benefits by fostering community resilience through the integration of traditional knowledge and innovative practices (Smith & Thongchai, 2020).

2.2.4. Economic and Social Contributions

CBEs play a transformative role in alleviating poverty, enhancing food security, and fostering inclusive growth. By enabling collaboration among

small-scale producers, they create sustainable livelihoods and empower marginalized communities. For instance, in Thailand's Deep South, micro and small enterprises have rejuvenated rural economies, boosting incomes and local autonomy (Elhoushy, 2020). CBEs also improve income distribution and market performance through strategic product and marketing innovations. These efforts often align with cultural and environmental values, ensuring that enterprise activities resonate with community priorities while meeting modern consumer demands (Chaochotechuang & Mariano, 2016).

2.2.5. Collaborative Frameworks for Sustainability

The sustainability of community-based enterprises (CBEs) is closely linked to their ability to leverage collaborative frameworks. The Triple Helix model, which promotes partnerships among government, academia, and industry, strengthens enterprise capacity by facilitating knowledge-sharing, access to advanced technologies, and market insights (Ueasangkomsate & Jangkot, 2017). In addition, non-governmental organizations (NGOs) play a critical role by enhancing business management skills, providing technical and financial support, and advocating for policy reforms that reduce bureaucratic barriers and improve resource accessibility (Sowcharoensuk, 2022). These collaborative mechanisms collectively empower CBEs to achieve long-term resilience and sustainable growth.

2.2.6. Challenges in CBE Development

Despite their potential, CBEs face several challenges that limit their growth and sustainability:

1. Limited Access to Financing: High interest rates and restricted credit availability hinder operational expansion and innovation (Distanont et al., 2019).
2. Bureaucratic Barriers: Complex regulations and administrative hurdles slow production and market entry, reducing competitiveness.
3. Market Volatility: Fluctuating demand and pricing in both local and export markets create uncertainty, requiring resilient strategies.

These challenges highlight the need for supportive policies, strategic innovation, and capacity-building initiatives to ensure CBE success.

2.2.7. Need for Innovation and Digital Integration

To unlock their full potential, CBEs must focus on product quality improvements, diversified offerings, and the integration of digital marketing strategies. Online platforms like Facebook and Shopee offer affordable and effective channels for boosting visibility, engaging directly with consumers, and increasing sales (Philip et al., 2022). Adopting sustainable practices, such as innovative packaging and standardized processes, also positions CBEs to meet the expectations of environmentally conscious consumers and global markets (Chaisawat, 2019). These advancements ensure their relevance and competitiveness in the long term.

2.2.8. Broader Implications

The impact of CBEs extends beyond economic benefits. By blending traditional and modern practices, they strengthen social cohesion and resilience in rural communities. This dual role as economic and cultural hubs makes CBEs indispensable to sustainable rural development.

Future strategies should prioritize:

- Enhancing resource access through public-private partnerships.
- Encouraging digital adoption in marketing and operations.
- Implementing training programs to improve managerial and technical capacities.

By addressing these priorities, CBEs can overcome existing challenges and fulfill their potential as drivers of rural development in Thailand and similar contexts worldwide.

2.3. Food Production Standards

Food production standards are crucial for ensuring product consistency, safety, and quality, particularly for community enterprises striving to expand their market presence. Standardization not only helps meet consumer expectations and regulatory requirements but also serves as a strategic asset for building trust and accessing new markets. Research highlights that compliance with food safety standards enhances competitiveness, marketability, and consumer confidence (Pongsiri et al., 2018; Nordin & Ruslan, 2022).

2.3.1. Importance of Standardization

Standardized food production processes offer several key benefits:

1. Improved Consistency: Clear guidelines minimize variability, ensuring uniform taste, texture, and nutritional value across batches.
2. Operational Efficiency: Streamlined workflows reduce waste, optimize resource utilization, and improve productivity.

3. Risk Mitigation: Adherence to food safety protocols prevents contamination and foodborne illnesses, safeguarding consumers and brand reputation.

In dried fish production, achieving consistency is particularly challenging due to traditional techniques and environmental variability, such as changes in temperature, humidity, and processing times. These factors often lead to inconsistent quality, reduced shelf life, and diminished market appeal, emphasizing the critical need for standardized processes (Chaisawat, 2019).

2.3.2. Facilitating Market Access

Adopting internationally recognized food safety standards, such as Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP), is a gateway for small enterprises to enter global markets. Certification ensures:

- Credibility in export markets, where regulatory scrutiny is stringent.
- Consumer confidence through transparency and adherence to safety protocols.
- Market differentiation by leveraging quality certifications to stand out in competitive landscapes (Teerawut & Nichols, 2020).

2.3.3. Challenges in Standardization for Small Enterprises

While standardization offers significant advantages, small enterprises face notable barriers:

1. Resource Limitations: Lack of infrastructure, advanced technology, and financial capacity hinder the adoption of modern production techniques (Natsuda et al., 2011).
2. Knowledge Gaps: Limited awareness of food safety regulations and certification processes restricts participation.
3. Market Constraints: Enterprises focused on local markets may deprioritize compliance with export standards, missing out on long-term benefits.

2.3.4. Public Policy and Standardization

Government interventions play a vital role in promoting food production standards among small enterprises. In Thailand, initiatives such as certification schemes and technical training workshops aim to bridge knowledge gaps and enhance compliance. These programs offer:

- Training on food safety practices.
- Subsidies and financial support for upgrading production facilities.
- Access to quality testing facilities for meeting certification requirements (Philip et al., 2022).

However, additional measures are needed to address persistent challenges like the high costs of certification and limited access to advanced technologies. Collaborative efforts between public agencies, NGOs, and the private sector are essential to overcoming these barriers.

2.3.4. Broader Implications

- Standardization has transformative implications for rural community enterprises, enabling them to improve product reliability and consumer trust while positioning themselves competitively in both domestic and international markets. For solar-dried fish rings, adopting standardized methods can:
- Enhance product quality to meet consumer and regulatory expectations.
- Extend shelf life, ensuring suitability for distant markets.
- Strengthen competitiveness in evolving marketplaces.

These advancements align with global trends emphasizing traceability, sustainability, and quality assurance, ensuring that community enterprises remain relevant and competitive in an increasingly demanding food production landscape (Pongsiri et al., 2018; Teerawut & Nichols, 2020).

2.4 Packaging Innovations in Food Products

Innovative packaging is vital in preserving the quality, extending the shelf life, and enhancing the marketability of food products. Effective packaging solutions not only protect against contamination and spoilage but also improve consumer appeal, especially for perishable goods like fish and seafood. Technologies such as vacuum sealing, modified atmosphere packaging (MAP), and the use of biodegradable materials have proven effective in maintaining product integrity and supporting sustainable practices (Chaisawat, 2019).

2.4.1. The Role of Packaging in Product Differentiation

Packaging plays a critical role in differentiating products in competitive markets. Aesthetic and functional designs can increase brand visibility and consumer engagement, particularly in processed or convenience foods. Enterprises that adopt innovative and sustainable packaging are more likely to attract eco-conscious consumers, who prioritize environmentally friendly materials like

biodegradable or recyclable options (Elhoushy, 2020).

For CBEs, adopting sustainable packaging not only positions their products as responsible and modern but also appeals to both local and global markets, enhancing marketability and credibility.

Impact of Innovative Packaging on Sustainability

Innovative packaging supports sustainability through:

1. Reducing Food Waste: Advanced technologies like MAP and vacuum sealing extend product shelf life, minimizing spoilage.
2. Lowering Environmental Footprint: Sustainable materials, such as plant-based polymers or recycled paper, reduce packaging waste.
3. Improving Supply Chain Efficiency: Durable packaging reduces losses during transit, ensuring product safety and enhancing logistics (Sowcharoensuk, 2022).

2.4.2. Challenges in Adopting Packaging Innovations

Small enterprises often face barriers to implementing advanced packaging, including:

1. Financial Constraints: The cost of high-quality materials and advanced packaging machinery is often prohibitive (Distanont et al., 2019).
2. Technical Expertise: Limited knowledge of modern packaging technologies hampers innovation.
3. Access to Supply Chains: Securing sustainable or advanced packaging materials can be challenging for smaller businesses.

2.4.3. Strategies for Overcoming Barriers

Overcoming these challenges requires collaboration between public agencies, private enterprises, and research institutions. Key strategies include:

- Government Support: Subsidies, grants, and technical assistance programs can offset costs.
- Training and Capacity Building: Workshops can equip producers with skills to adopt new packaging technologies.
- Partnerships with Research Institutions: Collaborations can provide access to tailored, cutting-edge packaging solutions.

For example, government-backed initiatives in Thailand have enabled CBEs to adopt sustainable packaging, improving their competitiveness in both local and international markets (Philip et al., 2022).

2.4.4. Broader Implications

For CBEs producing solar-dried fish rings, innovative packaging can:

- Extend Shelf Life: Advanced materials like laminated aluminum foil can double shelf life, ensuring suitability for distant markets.
- Improve Consumer Appeal: Functional features, such as resealable designs, cater to modern consumer demands for convenience.
- Support Sustainability Goals: Eco-friendly packaging aligns with global trends, enhancing market acceptance.

Packaging innovations that meet consumer demands for freshness, convenience, and environmental responsibility enhance product quality, competitiveness, and long-term sustainability (Elhoushy, 2020; Sowcharoensuk, 2022).

2.5 The Role of Digital Marketing

Digital marketing has emerged as a transformative tool for small enterprises, offering cost-effective solutions to expand market reach, strengthen brand loyalty, and engage directly with consumers. Platforms such as Facebook, Instagram, and Shopee enable rural enterprises to showcase products, interact with customers, and drive sales while bypassing traditional distribution channels.

2.5.1. Benefits of Digital Marketing for CBEs

1. Enhanced Consumer Engagement and Visibility: Social media platforms increase consumer interaction and brand visibility. Targeted advertisements, influencer collaborations, and personalized content foster trust and loyalty (Teerawut & Nichols, 2020).
2. Direct-to-Consumer Advantages: E-commerce platforms eliminate intermediaries, reducing costs, improving delivery times, and enabling producers to gather valuable customer feedback (Sowcharoensuk, 2022).
3. Data-Driven Insights: Digital tools provide market data and consumer preferences, enabling businesses to refine strategies, optimize pricing, and identify emerging trends.

2.5.2. Challenges in Digital Marketing Adoption

Despite its potential, CBEs face several challenges in adopting digital marketing:

1. Limited Digital Literacy: Many enterprises lack the technical expertise to navigate digital platforms effectively.
2. Infrastructure Gaps: Poor internet connectivity in rural areas hampers online operations (Ueasangkomsate & Jangkot, 2017).

3. Cybersecurity Risks: Increased reliance on digital tools exposes enterprises to fraud and data breaches, affecting consumer trust.

2.5.3. Collaborative Efforts to Foster Digital Marketing Adoption

To address these challenges, collaborative efforts are essential:

- Training and Capacity Building: Government-supported programs can improve digital literacy among CBE operators.
- Financial and Technical Support: Subsidies for internet access and funding for digital tools can lower barriers to entry. Collaborations with technology providers enhance technical capabilities (Philip et al., 2022).
- Infrastructure Development: Investments in rural internet infrastructure are crucial for consistent digital operations.

2.5.4. Relevance to Solar-Dried Fish Rings

Digital marketing can transform the marketability of solar-dried fish rings by:

- Increasing visibility among urban consumers via platforms like Shopee.
- Establishing direct-to-consumer sales channels to reduce reliance on physical markets.
- Highlighting product features, such as innovative packaging and ready-to-eat convenience, through engaging visual content.

2.5.5. Broader Implications

Digital marketing enables CBEs to adapt to changing consumer behaviors and market trends. It allows enterprises to:

- Promote Products Effectively: Customized advertising ensures targeted outreach.
- Build Consumer Trust: Real-time engagement fosters transparency and loyalty.
- Expand Market Access: Online platforms connect rural producers with domestic and global customers.

By integrating digital marketing, CBEs can strengthen brand recognition, develop loyal customer bases, and achieve sustainable growth in competitive markets (Elhoushy, 2020).

3. METHODOLOGY

3.1. Research Design

This study adopts a mixed-methods approach guided by the principles of Design Thinking to address the complex challenges faced by community-based enterprises (CBEs) producing solar-dried fish rings. By integrating qualitative and quantitative methods, the research captures both operational realities and consumer perspectives, ensuring a comprehensive understanding of production, marketing, and product quality issues. The Design Thinking framework provided a structured yet adaptive process, emphasizing stakeholder engagement, collaboration, and iterative refinement of solutions. The research followed the five stages of Design Thinking. In the Empathize stage, in-depth interviews and focus groups were conducted with producers to explore challenges such as inconsistent fish quality, limited resources, and environmental constraints. Consumer expectations regarding convenience, packaging sustainability, and market accessibility were also investigated. During the Define stage, qualitative data from these interactions were analyzed to identify core challenges, including variability in fish quality, limited shelf life, and insufficient marketing strategies, which were then synthesized into actionable problem statements. In the Ideate stage, collaborative workshops with producers, consumers, and industry experts generated innovative solutions focused on standardizing production processes, designing eco-friendly and functional packaging to extend shelf life, and enhancing digital marketing approaches to broaden market reach. These ideas were then translated into tangible interventions in the Prototype stage, where standardized production workflows, laminated aluminum foil and biodegradable packaging prototypes, and targeted digital campaigns on platforms such as Facebook and Shopee were trialed and evaluated for feasibility, cost-effectiveness, and functionality. Finally, in the Test stage, the effectiveness of these interventions was assessed through consumer acceptance surveys measuring satisfaction with packaging and product quality, as well as operational performance metrics evaluating production efficiency and cost reductions. Feedback from these assessments informed iterative refinements, ensuring solutions were practical, aligned with producer capabilities, and responsive to consumer needs. Overall, this Design Thinking–based approach enabled the co-creation of market-driven, sustainable solutions that enhance product quality, operational efficiency, and the competitiveness of CBEs. This methodology integrates diverse perspectives and emphasizes continuous improvement, providing a robust framework for addressing the operational and market challenges of CBEs in producing solar-dried fish rings.

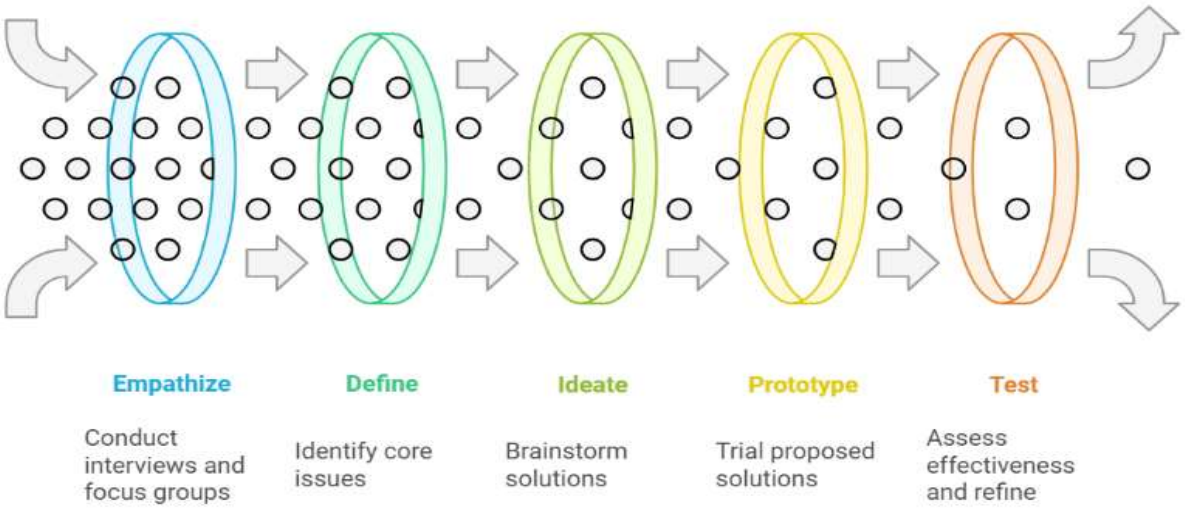

Figure 1: Design of Method on Design Thinking Process (Source: Authors).

This approach balances statistical precision from quantitative data with contextual insights from qualitative methods, ensuring both practical relevance and academic rigor (Pornchalermpong & Ratanapanond, 2021; Cui et al., 2023).

3.2. Key Informants and Participants

The study's key informants comprised two groups, including producers and consumers from Ubon Ratchathani province, selected to capture the diversity of stakeholders involved in the production and consumption of solar-dried fish rings. There are: (i.) 20 for CBE membership, and (ii.) 100 customers.

3.2.1. Sampling Methodology

Producers were purposefully selected based on their active membership and involvement in solar-dried fish ring production. Eligibility criteria included at least two years of experience in food production, familiarity with work processes and management within the CBE, and participation in research proposal submissions, grants, or other relevant initiatives. Both onsite and online interviews were conducted individually to recruit key informants, ensuring that insights were gathered from individuals directly engaged in operational and managerial aspects of production. Consumers were recruited through market research platforms to obtain a representative sample across urban and rural demographics. This approach allowed the study to capture diverse perspectives on product expectations, purchasing behaviors, and packaging preferences, ensuring that findings reflected the needs and perceptions of the target market.

3.2.2. Sample Size Determination:

To ensure representativeness and reliability, the sample size was determined using Taro Yamane's formula, which is widely recognized for establishing appropriate sample sizes in mixed-methods research (Pongsiri et al., 2018). This calculation provided a statistically robust foundation for the study, aligning with best practices in qualitative and quantitative data collection.

3.2.3. Focus Group Participants:

The study is designed to divide participants into two main groups: the producer section, which consists of 20 members from CBE, and 100 customers who are required to purchase a similar product within three months. In addition to the primary participants, five additional individuals including leaders and subordinates from CBE in Sirindhorn District, Ubon Ratchathani Province, Thailand—will be purposefully selected for focus group discussions. These participants have been chosen for their expertise in the following areas: (i.) Basic understanding of product development and related innovations, and (ii) Trends and uncertainties in consumer behavior, as well as the dynamics of a competitive market, and relevant strategies. Their contributions will provide in-depth insights focused on the specific case selected. For example, they will address the operational challenges faced by producers and explore potential strategic opportunities for scaling production and enhancing marketability. This careful selection of key informants aims to ensure a comprehensive understanding of the solar-dried fish ring value chain, integrating perspectives from both production and consumption contexts.

3.3. Data Collection Methods

The data collection process was designed in alignment with the principles of Design Thinking, employing a multimodal approach to capture comprehensive perspectives from both producers and consumers. This integration of qualitative and quantitative methods ensured robust and actionable insights.

3.3.1. Qualitative Methods

- Semi-structured Interviews: Five key informants, including members of the CBE administrative team (leader and assistant staff), participated in face-to-face interviews lasting 60–90 minutes. These interviews explored production challenges, operational constraints, and perceptions of proposed innovations, providing in-depth insights into strategic and practical needs. All co-researchers were involved in the interview process to ensure consistency and comprehensiveness.
- Focus Group Discussions: Twenty recruited participants engaged in collaborative Design Thinking sessions to identify operational barriers, generate ideas for process standardization, packaging innovations, and marketing strategies. These discussions promoted co-creation and enhanced stakeholder engagement.

3.3.2. Surveys

Consumer Preferences and Satisfaction Surveys: Surveys were administered to 100 consumers using convenience sampling to assess reactions to new packaging designs and ready-to-eat fish ring prototypes. The survey design was concise and user-friendly to facilitate quick responses while capturing meaningful insights.

3.3.3. Product Testing Trials and Laboratory Testing:

Prototypes - Incremental development of standardized production methods, packaging designs, and marketing strategies was conducted. Consumer feedback from testing trials was collected to iteratively refine prototypes, enhancing usability, product appeal, and market readiness. Laboratory analyses further validated product quality, nutritional content, and safety. This combination of qualitative and quantitative methods provided a comprehensive understanding of stakeholder perspectives, particularly those of producers and consumers, in line with best practices in mixed-methods research. The iterative feedback process further strengthened the validity and reliability of the findings (Pornchalermpong & Ratanapanond, 2021). In summary, Table 1 outlines the procedures and details regarding the technical data of the study. This multi-step approach integrated community engagement, field research, and laboratory analyses to enhance the quality, marketability, and sustainability of dried fish production. It combined empirical data collection, theoretical review, hands-on product testing, and knowledge transfer to ensure that interventions were practical, evidence-based, and aligned with community needs.

Table 1: Summary of Research Procedures.

Steps	Description	Laboratory Testing, Method & Equipment
1. Preparation Phase	Collect contextual data about the community, including local wisdom and production practices of the community enterprise producing dried fish using a solar dome in Sirindhorn District, Ubon Ratchathani.	Surveys, interviews, and field observation tools (e.g., notebooks, recording devices).
2. Literature Review	Study theories and prior research related to food production processes, branding, packaging development, and marketing channels.	Academic research databases, statistical analysis software.
3. Field Data Collection	Conduct on-site visits and gather data about the community's operational environment and production constraints.	Camera for documentation, GPS (if needed), and interview kits.
4. Community Workshops	Organize workshops to introduce and clarify project objectives to community enterprises involved in dried fish production.	Presentation equipment (projector, screen), printed materials, questionnaires.
5. Product Quality Analysis	Analyze dried fish samples for physical, chemical, and contamination parameters.	- Physical tests: Hunter Lab Colorimeter (Model Color Flex, Reston, USA). - Chemical tests: Thermogravimetric analyzer (Leco TGA701) for moisture content. - Water activity (aw): Novasina Lab Master-aw neo (Gerhardt, Germany). - Contaminants: AOAC methods for lead, mercury, cadmium, and arsenic.
6. Development Phase	Develop improved packaging and production processes based on findings to increase product value and shelf life.	Packaging design software, prototype testing kits.

7. Training & Knowledge Transfer	Conduct training for stakeholders on product standards and marketing strategies.	Training manuals, audiovisual materials.

3.4. Data Analysis

Data analysis combined quantitative statistical techniques with qualitative thematic methods to provide a comprehensive interpretation of the research findings. This integrated approach ensured a balanced understanding of operational and market challenges while generating actionable insights.

3.4.1. Quantitative Analysis

- Descriptive Statistics: Measures including mean, median, and standard deviation were applied to survey data, enabling the identification of trends in consumer satisfaction, purchasing behavior, and product preferences.
- Performance Metrics: Product testing trials were analyzed to evaluate operational feasibility, cost-effectiveness, and market potential of proposed interventions, such as standardized production processes and innovative packaging solutions.

3.4.2. Qualitative Analysis

Thematic Analysis: Focus groups and interviews were coded to identify recurring themes related to (i) operational challenges faced by producers, (ii) consumer preferences for packaging designs and product features, and (iii) marketing opportunities to enhance visibility and engagement. This dual-method approach ensured statistical rigor while capturing the contextual nuances of stakeholder perspectives, facilitating a deeper understanding of production and market dynamics (Meta-analysis of the Food Supply Chain, 2022).

3.5. Ethical Considerations

This study strictly adheres to ethical guidelines, prioritizing participant dignity, privacy, and autonomy throughout the research process (Creswell & Poth, 2018). **Key ethical measures include:**

- Informed Consent: All participants provided informed consent after receiving clear explanations about the study's objectives, methodologies, procedures, and their rights. Consent documentation was made available in both the original Thai and a back translation in English, intended for publication. In common oral communication, the Northeastern or Esan language was primarily used to foster a comfortable atmosphere during the research project. Additionally, this approach ensured full transparency and understanding for all participants.
- Confidentiality and Privacy: Participant data have been anonymized to maintain confidentiality, consistent with ethical standards for qualitative research (Kaiser, 2009). Measures to protect privacy included assigning codes to data sets to ensure the anonymity of individual responses.
- Cultural Sensitivity: The research was conducted with an acute awareness of and respect for Thai-Esan cultural norms, traditions, and religious values. Researchers engaged respectfully and appropriately with community stakeholders, including temple leaders, laypersons, and local community members, thereby ensuring culturally sensitive interactions (Liamputtong, 2010).

These ethical practices ensured the study's integrity and safeguarded the rights and welfare of all participants involved.

3.6. Summary of Methodology

This study employed a mixed-methods approach informed by Design Thinking to thoroughly investigate and address the production and market challenges associated with solar-dried fish rings. The methodology involved a purposive sample of two group of participants, including both producers (20) and consumers (100), to ensure comprehensive representation. Data collection included surveys, interviews, focus groups, and product testing trials, which provided a wide range of insights from stakeholders. The data analysis combined descriptive statistics to identify trends in consumer behavior and satisfaction, along with thematic analysis to uncover qualitative insights into production challenges and market opportunities. This integrated framework balanced academic rigor with practical relevance, resulting in actionable strategies to improve production standards, enhance marketability, and maximize the commercial potential of solar-dried fish rings.

4. RESULTS

The results of this study are presented in five key areas, illustrating how the integration of the Design Thinking framework addressed production challenges, enhanced product offerings, and improved market outcomes for solar-dried fish rings.

4.1. Development of Production Standards

Using the Design Thinking approach, standardized production methods were developed to ensure consistency and product quality. **The process followed the iterative stages of Design Thinking (Figure 2):**

1) Empathize: Focus groups and interviews with producers identified variability in fish sizes, suboptimal drying techniques, and the need for uniform standards to enhance product quality.
2) Define: Key challenges, including inconsistent fish sizing and preparation methods, were clarified, emphasizing their negative impact on consumer satisfaction and marketability.
3) Ideate: Collaborative workshops with stakeholders generated solutions such as optimal drying times, improved cleaning and preparation techniques, and standardized criteria for fish selection.
4) Prototype: Trial production runs were implemented, testing uniform scaling, cleaning, and solar-dome drying for 15 hours.
5) Test: Multiple batches were analyzed to validate consistency in size, texture, and nutritional quality.

Strategically, this standardized production framework not only ensures product reliability and consumer trust but also provides a scalable model for other CBEs seeking to improve operational efficiency and market competitiveness.

Finished Product Outputs: The product development process standardized fish species to carp, red-tailed whitefish, and kingfish, each measuring 8–10 cm to ensure uniformity. Nutritional analysis confirmed that 100 grams of dried fish rings provided 321.92 kcal, 52.6 g of protein, and notable levels of calcium and iron. Consistency in texture and taste contributed to improved consumer acceptance. The progression from prototype to final product is illustrated in Figures 2 and 3, highlighting the successful integration of standardization, nutritional optimization, and consumer-driven design. Strategically, these outputs demonstrate how standardization and quality control can enhance both market appeal and product reliability for CBEs.

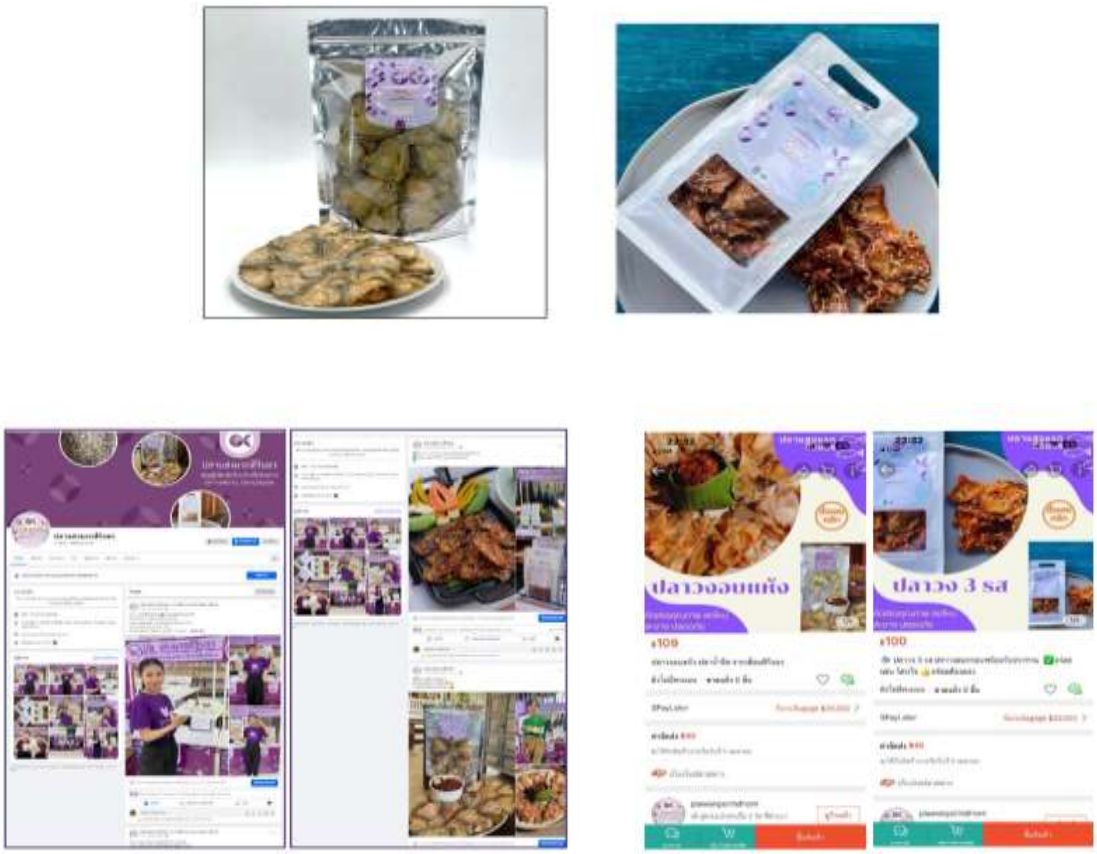

Figure 2: Prototype, Final Product, and Brochure.

Table 2: Nutritional Value of Standardized Solar-Dried Fish Rings (Per 100 grams).

Nutrient Component	Amount per Serving
Energy	321.92 kcal
Protein	52.6 g
Calcium	3247.07 mg
Iron	1.93 mg
Cholesterol	443.99 mg

These production standards address producer challenges while meeting consumer expectations and regulatory requirements, supporting market competitiveness.

Figure 3: The stages of Design Thinking guided the process.

4.2. Product Development of Ready-to-Eat Crispy Fried Fish Rings

Building on insights from the Empathize and Define stages, producers co-developed a ready-to-eat crispy fried fish ring variant. During the Ideate stage, flavors such as tamarind juice, chili powder, paprika, and white sesame were introduced to align with consumer preferences for spicy and savory snacks. In the Prototype stage, hot air ovens were employed to fry the fish rings, ensuring crispiness while retaining nutritional value. Testing demonstrated that laminated aluminum foil packaging extended shelf life to 30 days, enhancing convenience and reducing waste. Finished Product Outputs: Consumer testing yielded positive feedback, validating the product's flavor, convenience, and overall quality. Nutritional analysis indicated that 100 grams of the product contained 334.96 kcal, 44.07 g of protein, and 24.28 g of carbohydrates. Strategically, these outcomes highlight the successful integration of consumer-driven innovation, quality preservation, and market-ready packaging, providing a model for sustainable product development in CBEs.

Table 3: Nutritional Components of Crispy Fried Fish Rings (Per 100 grams).

Nutrient Component	Amount per Serving
Energy	334.96 kcal
Protein	44.07 g
Carbohydrates	24.28 g
Fat	6.84 g
Sodium	1494.75 mg

This innovation diversifies the product line, meeting market demand for convenience and flavor while appealing to a broader consumer base (Figure 4).

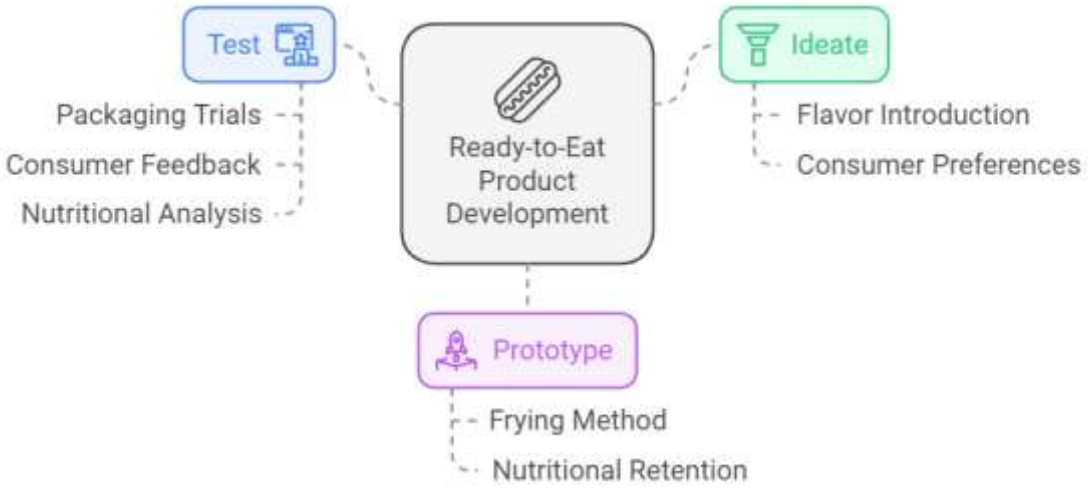

Figure 4: Diversification of Innovation on Consumer Bases.

4.3. Innovative Packaging and Consumer Response

During the prototype stage, innovative packaging solutions were developed to address concerns about freshness and sustainability. Laminated aluminum foil packaging effectively doubled the shelf life of fish rings from 15 to 30 days. Consumer feedback indicated 85% satisfaction with the resealable design, underscoring both its functional benefits and market appeal. Strategically, these packaging innovations not only enhance product quality and convenience but also strengthen brand differentiation and support sustainable market positioning.

Table 4: Comparison of Packaging Performance.

Packaging Type	Shelf Life	Consumer Satisfaction
Traditional Packaging	15 days	Moderate
Laminated Foil Package	30 days	High (85% approval)

This innovation aligns with modern consumer expectations for sustainable and functional packaging while supporting product quality and marketability (Figure 5).

Figure 5: Alignment of Innovation with Modern Consumer Expectations.

4.4. Consumer Acceptance Surveys

To evaluate consumer satisfaction with the new product versions, a survey was administered to 100 participants selected through convenience sampling. The questionnaire employed a 5-point Likert scale (1 = not very satisfied, 5 = very satisfied) to assess satisfaction with both packaging and product quality. Participants were volunteers who had prior experience with local food shopping or consumption, ensuring familiarity with the product category. No adverse effects or biases were identified from these prior experiences, allowing the data to reliably capture consumer perceptions of the new product designs. Respondent Demographics: The survey included 100 participants, recruited to represent both urban (60%) and rural (40%) consumers. Gender distribution was balanced, with 52% female and 48% male respondents. Age groups ranged from 18 to over 56 years, with the largest proportion between 26–35 years (30%). Educational backgrounds varied from high school or lower (20%) to undergraduate degrees (15%), while occupational categories included employees/workers (50%), self-employed/entrepreneurs (25%), students (15%), and retired/other (10%). This diverse sample ensures that the survey results reflect a broad spectrum of consumer perspectives, supporting the reliability and generalizability of findings regarding packaging and product quality preferences. The findings are demonstrated in Table 5 & 6.

Table 5: Packaging Design Scores.

Dimension	Mean Score	SD	Interpretation
Visual Appeal	4.3	0.5	High acceptance
Functionality / Usability	4.0	0.6	High usability
Informational Clarity	3.9	0.7	Moderate to high clarity
Sustainability / Eco-Friendliness	4.1	0.6	Positive perception
Safety / Protection	4.2	0.5	High protection satisfaction
Overall Packaging Score	4.1	0.5	High overall acceptance

Table 5 summarizes consumer evaluations of packaging design. All dimensions scored highly, with visual appeal (4.3) and safety/protection (4.2) rated strongest, while informational clarity scored slightly lower (3.9). The overall packaging score of 4.1 (SD=0.5) indicates high consumer acceptance. Strategically, these results suggest that enhancing visual appeal and ensuring product protection can reinforce brand trust, while improving informational clarity could further differentiate the product and strengthen market competitiveness.

Table 6: Product Quality Scores.

Dimension	Mean Score	SD	Interpretation
Taste / Flavor	4.4	0.5	Very high satisfaction
Texture / Consistency	4.1	0.6	High satisfaction
Freshness / Shelf Life	4.0	0.7	Moderate to high
Nutritional Value / Healthiness	3.8	0.8	Moderate perception
Overall Satisfaction	4.2	0.5	High overall satisfaction
Overall Product Quality Score	4.1	0.6	High overall satisfaction

Table 6 presents consumer evaluations of product quality across five dimensions. Taste/flavor received the highest score (4.4), reflecting very high satisfaction, followed by texture/consistency (4.1) and freshness/shelf life (4.0). Nutritional value/healthiness scored moderately (3.8). The overall product quality score of 4.1 (SD=0.6) indicates high overall consumer satisfaction. From a strategic perspective, these results highlight the importance of taste and texture in driving consumer acceptance, while emphasizing opportunities to enhance perceived healthiness and nutritional value to appeal to health-conscious markets and strengthen competitive positioning.

4.4. Digital Marketing Strategies and Outcomes

Digital marketing strategies were implemented using platforms such as Facebook and Shopee. Targeted promotions effectively increased consumer awareness and engagement, while online sales channels enabled direct-to-consumer interactions, strengthening brand loyalty and reducing distribution costs. As shown in Table 7, these initiatives resulted in a 20% increase in online orders within three months, and significant revenue growth, demonstrating the effectiveness of digital campaigns in expanding market reach and enhancing overall business performance.

Table 7: Performance Metrics.

Metric	Value
Increase in Orders	20%
Revenue Growth	Significant
Platforms Utilized	Facebook, Shopee

These findings demonstrate the transformative potential of digital marketing in enhancing CBE visibility and competitiveness (Figure 6).

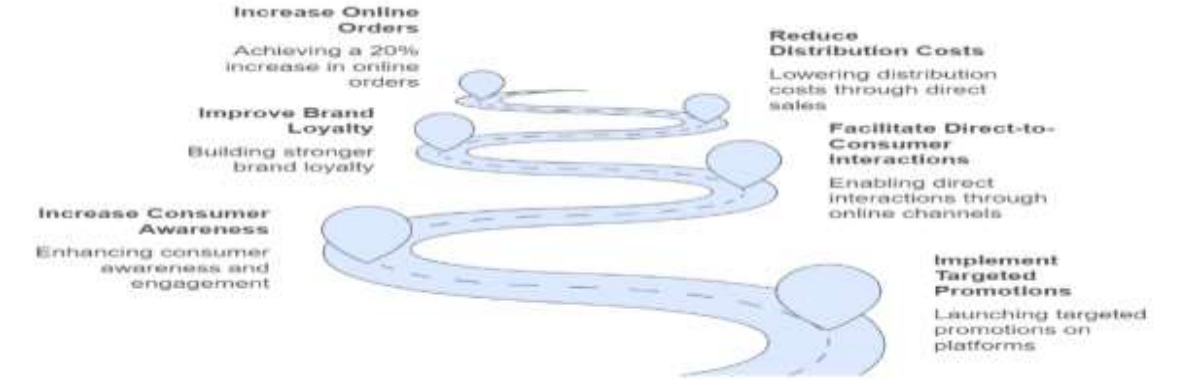

Figure 6: Impact of Digital Marketing Strategies.

4.5. Cost Analysis and Economic Impact

The introduction of standardized processes and innovative packaging significantly reduced production costs in Table 8.

Table 8: Cost Control and Economic Impact.

Metric	Before Standardization	After Standardization	Change (%)
Production Cost (per bag)	55.06 baht	41.80 baht	-24.08%

Figure 7 provides the slightly movement in side of financial aspect. In These economic gains highlight the importance of process optimization and strategic pricing in enhancing market competitiveness and sustainability (Figure 7).

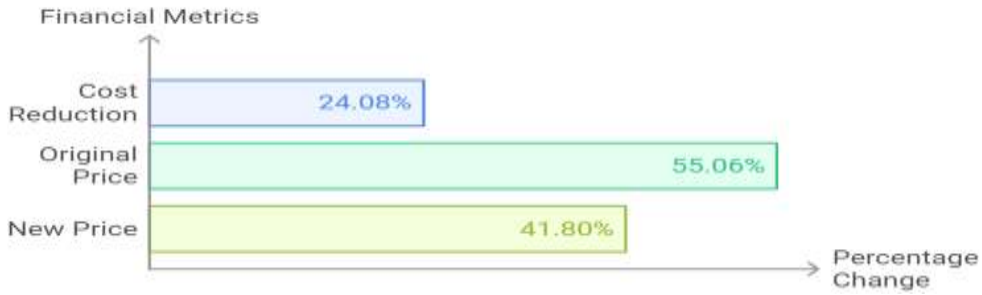

Figure 7: Financial Metrics.

With the data presentation above, the new standardization of production processes led to a significant reduction in costs, lowering the per-bag production cost from 55.06 baht to 41.80 baht, a 24.08% decrease. This cost efficiency not only improves profitability but also enhances the competitiveness of the product in the market, enabling the enterprise to allocate resources toward innovation, quality improvement, and strategic marketing initiatives.

The results (Figure 8) demonstrate co-creation, the effectiveness of the Design Thinking framework in overcoming operational challenges, improving product offerings, and stimulating market growth for solar-dried fish rings. By employing an iterative, user-centered approach, the framework ensured that solutions were not only innovative and practical but also closely aligned with producer capabilities and evolving consumer expectations. Strategically, this approach supports continuous product refinement, enhances competitiveness, and fosters sustainable enterprise development in dynamic market environments.

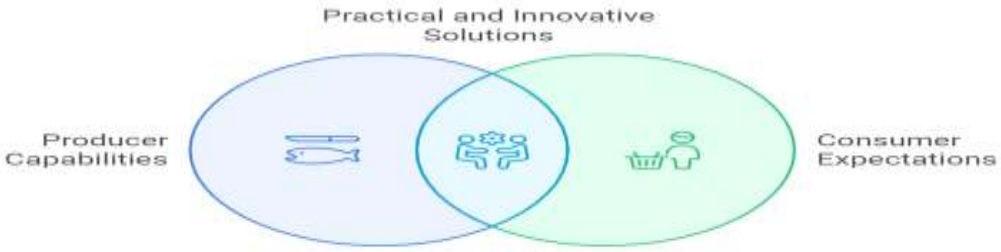

Figure 8: Stakeholders' Co-Creation.

5. DISCUSSION

This study highlights the transformative potential of the Design Thinking framework in tackling the production, packaging, and marketing challenges faced by community-based enterprises (CBEs) that produce solar-dried fish rings. The findings are consistent with existing literature on food production and rural enterprise development, emphasizing the importance of incorporating stakeholder insights and using iterative methodologies to achieve sustainable innovation.

5.1. Enhancing Production Standards through Empathy-Driven Processes

The integration of the Empathize and Define stages in the production standardization process was crucial for identifying core challenges, such as variability in fish sizes and inadequate drying techniques. These findings align with Chaisawat (2019), who highlights the difficulties of maintaining consistent quality in small-scale food enterprises. The collaborative nature of the Ideate and Prototype stages allowed producers to co-develop solutions, fostering a sense of ownership and practicality in the standardized processes. Testing validated these methods, resulting in improved product consistency and nutritional value. This approach reflects the findings of Distanont et al. (2019), who emphasize the importance of iterative co-creation in enhancing operational efficiency in rural enterprises.

5.2. Product Diversification for Market Relevance

The development of ready-to-eat fried fish rings has effectively addressed consumer demand for convenience and flavor, showcasing the significance of product diversification in adapting to changing market trends. The positive reception of this product highlights how the Ideate and Prototype stages can successfully align new offerings with consumer expectations, as noted by Ueasangkomsate and Jangkot (2017). Additionally, the use of laminated foil packaging has extended the product's shelf life, further enhancing its appeal and suitability for wider distribution. This finding is in line with the work of Philip et al. (2022), who emphasize the importance of packaging innovations in boosting the competitiveness of small enterprises.

5.3. Packaging Innovations and Sustainability

The adoption of laminated aluminum foil packaging addressed two critical consumer concerns: product freshness and environmental impact. Extending shelf life by 100% and incorporating resealable designs demonstrated the ability of innovative packaging to meet modern consumer demands for convenience and sustainability. This aligns with the increasing trend of eco-conscious consumer behavior, as highlighted by Elhoushy (2020). It emphasizes the need for consumer brand engagement (CBE) to adopt packaging solutions that effectively balance functionality with environmental responsibility. The high satisfaction rate of 85% among consumers further supports the importance of user-centered design in packaging development.

5.4. Leveraging Digital Marketing for Market Expansion

The integration of digital marketing strategies through platforms like Facebook and Shopee has significantly expanded market reach and increased sales, demonstrating the effectiveness of online tools in enhancing the visibility of community-based enterprises (CBEs). The 20% rise in online orders supports the findings of Sowcharoensuk (2022), who identified digital platforms as essential for rural enterprises aiming to overcome traditional distribution barriers. However, challenges such as limited digital literacy and infrastructure gaps, as noted by Ueasangkomsate and Jangkot (2017), continue to pose significant obstacles. To sustain the long-term benefits of online marketing, it will be crucial to address these issues through training programs and investments in digital infrastructure.

5.5. Economic Impact and Sustainability

The reduction in production costs by 24.08% and the subsequent price adjustment from 55.06 to 41.80 baht per bag highlight the economic advantages of process optimization and innovative packaging. These improvements not only enhanced the competitiveness of the enterprise but also contributed to increased annual revenue, ensuring its long-term sustainability. The study's findings resonate with the observations of Nordin and Ruslan (2022), who emphasize the role of standardization and innovation in improving operational efficiency and market positioning for small enterprises.

6. SUMMARY AND CONCLUSION

This study investigated the application of the Design Thinking framework to enhance the competitiveness, operational efficiency, and market reach of Community-Based Enterprises (CBEs), using solar-dried fish rings as a case study. Key findings demonstrated that standardized processes, product diversification, innovative packaging, and digital marketing significantly improved consumer satisfaction, product quality, and overall business performance. Consumer surveys indicated high acceptance of packaging and product quality, while cost standardization reduced production expenses by 24%, contributing to economic resilience. Strategically, the study highlights the importance of aligning product development and marketing strategies with consumer expectations and sustainability trends. The integrated framework provides a replicable model that can be applied to other products, such as dried fruits and vegetables, and emphasizes the value of continuous training, digital literacy, and cost control for long-term viability. Future research should explore the scalability of these interventions, the long-term economic impact on CBEs, and the integration of circular economy principles to further enhance sustainability. Overall, the study confirms that Design Thinking offers a practical, user-centered approach to solving operational challenges, fostering innovation, and promoting sustainable growth in CBEs, thereby supporting their competitiveness in dynamic markets.

6.1. Broader Implications for Community-Based Enterprises

The study proposes a replicable model for Community-Based Enterprises (CBEs) seeking to modernize operations and expand market access. The model emphasizes four key components: standardized processes to ensure consistency, quality, and regulatory compliance, thereby building consumer trust; product diversification to meet evolving consumer demands while fostering innovation; innovative packaging that enhances product appeal and sustainability in line with global trends; and digital marketing strategies to broaden market reach and enable direct-to-consumer engagement. By integrating the Design Thinking framework, CBEs can implement these strategies effectively while maintaining the flexibility to respond to dynamic market conditions, ultimately supporting sustainable growth and long-term competitiveness.

6.2. Research Limitations

While this study successfully demonstrated the application of Design Thinking to address key operational and market challenges, several limitations should be acknowledged. First, the geographic focus on the Sirindhorn District may limit the generalizability of findings, and adaptations may be necessary for other regions or product types. Second, limited digital literacy among producers constrained the scalability of online marketing strategies, highlighting the need for ongoing capacity-building and continuous training programs to ensure sustainable digital engagement. Third, for CBEs to remain competitive and viable, rigorous cost control across all operations is essential, alongside careful monitoring of both sales volume and profitability to support effective business planning and long-term sustainability.

6.3. Future Research

Future research and practical applications could explore the scalability of these interventions to other products, such as dried fruits or vegetables, to assess broader applicability. Additionally, the long-term impact of these innovations on the economic resilience of CBEs warrants investigation, providing insights into sustained growth and competitiveness. Integrating circular economy principles into production and packaging processes also presents an opportunity to further enhance environmental sustainability while reducing costs and resource consumption, aligning CBEs with global sustainability standards and consumer expectations.

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