



Integrating Local Wisdom into Innovative Antibacterial Finishing of Local Handwoven Brocade Textiles for Sustainable Cultural Textile Development (SDG 9)

Jaipak Burapajatana^{1*}, Somporn Bhurichotitham², Narong wichairat³, Wanchai Boonrod⁴, Qian Wu⁵

¹Shinawatra University, Faculty of Liberal Arts, Thailand, Research Fellow, INTI International University, Malaysia. ORCID: 0009-0003-1375-6181, E-mail: Jaipak.b@siu.ac.th

²Faculty of Fine and Applied Arts, Rajamangala University of Technology Thanyaburi, Thailand ORCID: 0009-0003-3286-4620, E-mail: Somporn_V@Rmutt.ac.th

³Shinawatra University, Faculty of Education, Thailand. ORCID ID:0009-0004-9969-482X, E-mail: narong.w@siu.ac.th

⁴Independent researchers. E-mail: bwanchai60@gmail.com

⁵Guizhou Qian nan College of Science and Technology, China. ORCID: 0009-0009-1241-0043, E-mail: 3159125077@qq.com,

Abstract

This study aimed to integrate local wisdom with innovative antibacterial finishing technology to enhance the functionality and sustainability of Lamphun handwoven brocade textiles. The study employed a mixed-method approach combining qualitative assessment, laboratory experimentation, and satisfaction evaluation. A prototype of Lamphun brocade textile was treated with micro-particle-based Quat Silane antibacterial agent at a concentration of 80 g/L and dried at 150°C for 90 seconds. Antibacterial performance was evaluated according to AATCC 147 using *Staphylococcus aureus* ATCC 6538 and *Klebsiella pneumoniae* ATCC 4352. The results showed no bacterial growth on the treated fabric, with a 3.5 mm inhibition zone against *S. aureus*. The overall consumer satisfaction among 100 consumers was high, while satisfaction among 10 experienced weavers was also high. The findings indicate that antibacterial finishing can improve the functional value of traditional textiles while maintaining their aesthetic qualities, patterns, and cultural identity. The study recommends further development and application of textile material technologies to strengthen community-based production, enhance product value, and support the sustainable preservation of local textile wisdom.

Keywords

Local Handwoven Brocade Textiles; Antibacterial Finishing; Textile Innovation; Sustainable Cultural Textiles Development; Quat Silane Micro-particles.

Available Online: 10/09/2026

Introduction

Lamphun Brocade is a renowned traditional textile product of Lamphun Province in Thailand from its prominent intricate raised patterns, refined weaving technique and use of high-quality silk or cotton threads which reflect deep-root of the local wisdom and cultural identity of the community. Lamphun Brocade is a sophisticated handicraft that required artistic precision and skill-craftsmanship at every stage of making; from yarn preparation, dying to meticulous technique of lifting patterns. As a result, Lamphun Brocade then possesses exceptional artistic and cultural value to earn both national and international recognition.

Lamphun Brocade has been registered as a Geographical Indication (GI). Nowadays, Hariphunchai Handwoven Textile Institute in Ton Thong Subdistrict of Lamphun province has been established by Lamphun Provincial Administrative Organization. This institute has a purpose to preserve culture and unique of traditional weaving fabrics of Lamphun which has long history. Within the institute is located a museum of several ancient textiles. Besides the institute also serves as a learning center of design for traditional motifs and patterns as well as the career-fostering center for weavers and wish to pass on their experience and wit to publics.

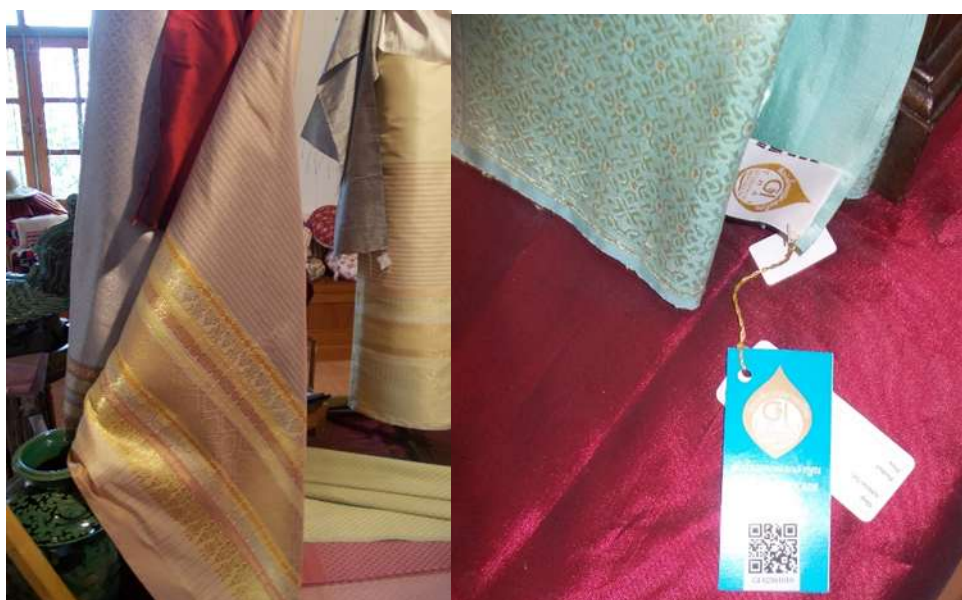


Figure 1. Lamphun Brocade weaving and Geographical Indication (GI) of Hariphunchai Handwoven Textile Institute of Lamphun Province, Thailand.

Source: Jaipak Burapajatana, 2023

Traditional textiles product nowadays, however, is challenged by change of economic and consumer behaviors (Thimakham, 2015)., particularly in respect of functionality, durability and hygiene. Present consumers tend to prioritize products which are safe from pathogens and compatible with modern lifestyle. Development of textiles with antibacterial property become an important approach to enhance value and competitiveness of local handwoven textiles.

In the past, innovation of antibacterial substance was mostly from natural extracts which limited in terms of property for bonding stability and effectiveness. Recent research, however, has focused on antibacterial technology and Quat Silane which is a micro-particle with antibacterial has been used. Quat Silane reveals its superior in terms of chemical bounding, stability, high washing durability and effectiveness in bacteria inhibition without damaging fabric texture or colour.

This research aims to develop and innovative antibacterial finishing process for Lamphun Brocade textiles that applied by Quat Silane which is a micro-particle substance. This integration of science with local wisdom will enhance capability and value of community-based products, as well as fostering cultural local textiles industry to sustainable development within the frame of creative economy.

Literature Review

Local Wisdom and Cultural Identity in Lamphun Brocade Weaving

Lamphun Brocade weaving is a long-standing culture and tradition in northern region of Thailand which has prominent characteristics from intricate patterns and sophisticate weaving technique that embodies community identity and craftsmanship (Kongprasert, 2021; Bangbon et al., 2026; Fei et al., 2026). Weaving process of the brocade requires artistic sensibility and technical precision which pass on from generation to generation. Local artisans integrate cultural motifs, natural colors and symbolic patterns that reflect heritage of the region's wit

Satchasomboon and Techatekeng (2016) conducted the research titled "Strategies for Differentiating 5-Stars OTOP Fabric Products (Brocade Silk) of Entrepreneurs in Lamphun Province," to analyze for differentiation strategies used by sole proprietorships and community entrepreneurs in terms of concept for competitive factor analysis, factors of mixed-market, service factor and differentiation strategies. The finding reveals that sole proprietorships and businesses incorporate innovation in design to create distinctive product differentiation to increase its value and their price is higher than average market value due to their uniqueness characteristic.

Nevertheless, consumer-choices for textiles product and industrial textile production have challenged tradition weaving communities which resulted in necessity to integrate innovation with authenticity's preservation (Nimnual, 2022; Phasuk et al., 2026). Integration of modern scientific knowledge with practices has been identified as a key strategic for sustain local textile heritage.

Antibacterial Finishing and Textile Innovation

Antibacterial finishing is a surface modification process for microbial growth inhibition on fabrics to improving hygiene and extending its lifespan (Zhang, L et al., 2021). Among various antibacterial agent, Quat Silane agents which is ammonium quaternary salt silane base substance revealed superior efficiency in its lifespan than previous conventional antibacterial agents due to its covalent bond with cellulose and protein fibers (Li & Chen, 2022). Micro particle Quat Silane also has strong durability against washing and environment degradation while still maintaining breathability and texture of the fabrics (Wang et al., 2023). Recent study has emphasized the needs to apply innovations with natural local handwoven textiles in order to enhance their competitiveness and safety-standard (Chen et al., 2024). Nevertheless, applying of artificial micro-particles with local handwoven textiles is still limited, particularly in small-scale and the community-based production.

Integrating Science and Local Wisdom for Sustainable Cultural Textiles

Sustainable Cultural Textiles Development requires a holistic approach that integrates traditional craftsmanship with science innovation (Thammasart, 2021). This concept aligns with the framework of UNESCO for safeguarding intangible cultural heritage through creative transformation (UNESCO, 2020). In Thailand, local wisdom is tending to be used in modern design and production, particularly in projects in relation with craftsmanship and material science and eco-friendly projects (Wong et al., 2025).

Merging local weaving wisdom with innovation of antibacterial material can enhance functional and symbolic value to textiles product of the community which is not only to preserve traditional knowledge, but also to foster new economic opportunity under the economy paradigm (Chanuwong et al., 2025). Integration of Quat Silane antibacterial finishing with Lamphun brocade weaving, therefore represent an innovative model of sustainable cultural textile development and balancing of cultural continuity with technological advancement. (Shao et al., 2025).

Research Objectives

1. To test antibacterial efficacy by using micro-particle-based Quat Silane on local handwoven brocade Lamphun textiles.
2. To integrate local weaving wisdom with scientific innovations for a pathway of sustainable development for local handwoven textiles.

Research Methodology

Scope of the Research

Content Scope:

The research focused on studying and testing antibacterial finishing process by micro-particle-base Quat Silane which applied to Lamphun brocade handwoven fabrics. Laboratory experiments and qualitative studies were conducted to evaluate antibacterial performance. Physical properties of fabric and acceptance from weavers who have professional weaving experience in the community and consumers.

Geographical Scope:

The study was conducted in Lamphun Province, Northern Thailand—specifically among community weaving groups that preserve traditional brocade weaving techniques, "Hariphunchai Handwoven Textile Institute"

Population and Sample:

- 10 professional Lamphun hand weavers brocade textiles who have at least five years weaving experience, 100 handwoven textiles consumers.
- A prototype sample of Lamphun Brocade textiles of which colors, motif, patterns and specific material were designed by the researcher, and finished by micro-particle-base Quat Silane for efficiency tests on antibacterial property and physical performance.

Methodological Scope:

The research was carried out by mixed-method from integrating qualitative data obtained from questionnaires for satisfaction to antibacterial fabrics, and result of analysis from the laboratory for experiment data for physical and antibacterial properties.

Conceptual Framework

This research combines concepts from the review of studies on “Strategies to Differentiate 5-Star Silk Products of Entrepreneurs in Lamphun Province (Satsomboon & Techateken, 2016)” and “Integrating Scientific Knowledge with Traditional Practices (Nimnuan, Chiang Mai University Science Journal, 2022)” with local wisdom in traditional Lamphun silk weaving. It introduces innovations in textile materials by adding antibacterial Quat Silane coating particles to enhance the functionality and hygiene of indigenous textiles while preserving cultural identity and traditional aesthetic beauty. This approach serves as a sustainable way to promote value in the community's cultural textile production industry.

Conceptual Framework Diagram:

Table1: Conceptual Framework of the Study

Variables	Key Elements	Role in Framework
Local Wisdom in local handwoven brocade Lamphun textiles	Traditional techniques, motifs, cultural identity	Independent Variable (IV)
Textile material science innovation	Antibacterial finishing using Quat Silane micro-particles	Independent Variable (IV)
Enhanced antibacterial efficiency	Improved bacterial inhibition performance	Mediating Variable (MV)
Preservation of Traditional Aesthetic and Texture	Maintained appearance and hand feel	Mediating Variable (MV)
Functional quality	Optimizing the performance of woven fabrics to promote good hygiene.	Mediating Variable (MV)
Prototype Innovative Local handwoven brocade Lamphun textiles	Handwoven fabric with antibacterial properties	Dependent Variable (DV)

Variables	Key Elements	Role in Framework
Strengthened Community-based Production	Artisan participation and local capacity building	Dependent Variable (DV)
Sustainable cultural textile development	Cultural preservation and long-term sustainability	Dependent Variable (DV)

Source: Jaipak Burapajatana, 2025

Conceptual Relationship

Integration of local wisdom with innovative textile material science to Lamphun brocade is a way to develop local woven fabric. Improving antibacterial efficiency and durability property while still maintain traditional aesthetic and texture of the fabric pave a way to strengthen community base production and sustainable development of cultural textiles.

Research Results

Antibacterial Formulation Development:

Experiment was carried out in the laboratory to obtain proper criteria for solvent ratio and coating condition (temperature, curing time, concentration) and the formula which give most effective result for inhibiting bacteria.



Figure 2. Local handwoven brocade Lamphun textiles used in the experiment, designed by the researcher. Source: Jaipak Burapajatana, 2024



Figure 3. Local handwoven brocade Lamphun textiles prototype used in the experiment, designed by the researcher. Source: Jaipak Burapajatana, 2024



Figure 4. Costume design from local handwoven brocade Lamphun textiles used in the experiment. (Source: Jaipak Burapajatana, 2024)



Figure 5. Costume design from local handwoven brocade Lamphun textiles used in the experiment. (Source: Jaipak Burapajatana, 2024)



Figure 6. Costume design from local handwoven brocade Lamphun textiles used in the experiment.

Results of the development of antibacterial formulas

Purpose of applying antibacterial finishing to textile is for inhibiting the growth of bacteria. Which are one of causation of various skin diseases and unpleasant odour such as seat odour, body odour which cause acne, boils and infection in wounds etc. The antibacterial agent used to develop fabrics made of silk and rayon fiber is the micro particle type antibacterial agent Quat Silane. It is a substance that suitable for cellulose fiber, protein fibers, cellulose fibers mixed with other fibers. It is a substance that can be used to decorate fabrics to prevent bacteria. Process of the research and developing formula for the antibacterial coating solvent are as follows:

(THTI).



Figure 7. Testing the development of antibacterial formulas on local handwoven brocade Lamphun textiles by Textile Industry Development Institute (THTI) (Source: Industry Development Institute -THTI)

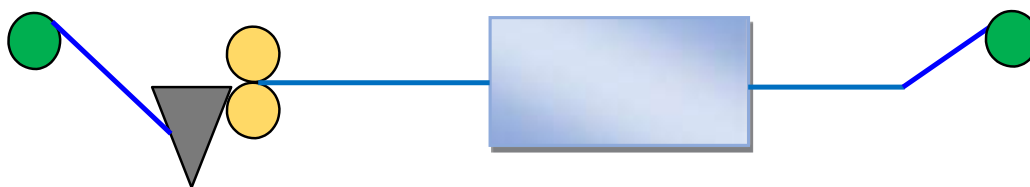


Figure 8 Finishing Application, 80 g/L concentration of Quat Silane antibacterial agent. Dry the fabric surface at 150°C. Tested by the Textile Industry Development Institute (THTI).

(Source: Industry Development Institute-THTI)

The experiment from Figures 7, 8 were carried out by dipping the sample fabric into chemical solvent which contains 80 g/L Quat Silane antibacterial agent and dry the fabric at 150° for 90 seconds. Thereupon, the sample was taken to analyze for antibacterial efficiency according to AATCC testing standards 147 by using *Staphylococcus aureus* ATCC6538 and *Klebsiella pneumoniae* ATCC4352. The result of AATCC 147 standard antibacterial efficacy test revealed the sample fabric which treated with Quat Silane antibacterial agent inhibit both gram-negative and gram-positive bacteria. It can stop growing of bacteria on the fabric and showed positive inhibition efficiency against gram-positive bacteria (*Staphylococcus aureus*). Moreover, bacterial inhibition efficiency could extend 3.5 mm. over edge of the test-area. Result of the test according to the laboratory report could be summarized to table 2 as follows:

Table 2: Result of the test according to the laboratory report

Local handwoven brocade Lamphun textile, brown color.		
FIBER CONTENT: Silk, Rayon		
Bacteria used for testing	BACTERIA GROWTH	ZONE OF INHIBITION (mm)
- <i>Staphylococcus aureus</i> ATCC 6538	NO GROWTH	3.5

- <i>Klebsiella pneumonia</i> ATCC 4352	NO GROWTH	0
---	-----------	---

Remark - Sample's condition as received from client

- Zone of inhibition is at edge of sample which has no bacteria

Calculated from below formula

$$W = \frac{T \cdot D}{2}$$

Where W = zone of inhibition in mm.

T = Diameter of sample and zone of inhibition (mm.)

D = Diameter of sample (mm.)

Table 3: Evaluation of Consumer Satisfaction with the Antibacterial Properties of local handwoven brocade Lamphun textile

Item	Most	High	Moderate	Low	Mean ($\bar{x}$)	S.D.	Interpretation
1. Utility	70	22	8	–	4.11	0.3	High
2. Appropriateness of Materials	70	30	–	–	4.15	0.24	High
3. Color Groups of Textiles	71	20	9	–	4.21	0.21	High
4. Textile Patterns	79	21	–	–	4.6	0.3	High
5. Fineness and Aesthetic Quality	82	18	–	–	4.67	0.3	Highest
6. The use of antibacterial agents on clothing	80	20	–	–	4.21	0.35	High
7. Suitability for use	65	22	13	–	4.21	0.29	High
8. Antibacterial Textile Innovation	86	14	–	–	4.82	0.2	Highest
9. Identity of local handwoven brocade Lamphun textile	70	19	11	–	4.63	0.21	Highest
10. Appropriateness to Current Context	78	22	–	–	4.71	0.29	Highest
Overall	–	–	–	–	4.43	0.26	High

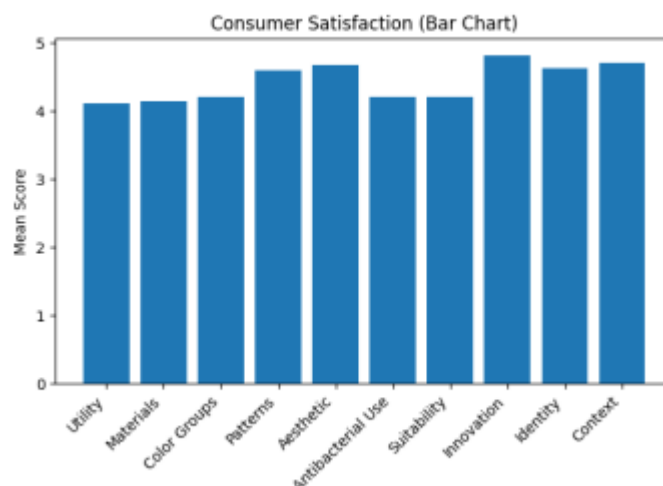


Figure 9. The chart shows the results of evaluation of consumer satisfaction with antibacterial properties of local handwoven brocade Lamphun textile.

Result of satisfaction of sample 100 consumers can be summarized as follows:

Consumers satisfied with Lamphun woven brocade with antibacterial property showed overall average score at 4.43 and standard deviation at 0.26 which considered high and indicate that consumers have high satisfaction with overall products.

In terms of satisfaction, the highest score was for antibacterial fabric innovation ($\bar{x} = 4.82$), followed by appropriateness to the current context ($\bar{x} = 4.71$), sophistication and aesthetic value ($\bar{x} = 4.67$) and identity of Lamphun weaving brocade ($\bar{x} = 4.63$). This reflects consumers' acceptance of innovation, quality and identity of the product.

In respect of usage, material suitability, textile patterns, textile design, the use of antibacterial agents on clothing and suitability for use all of them received average high score which indicate that the products meet with demand of the consumers. (Yayah et al., 2025).

Result of evaluation of experienced Lamphun hand weavers' satisfaction with antibacterial properties of local handwoven brocade Lamphun textile.

Table 4: Result of evaluation for satisfaction of experienced hand-weavers of Lamphun for antibacterial property of Lamphun woven brocade.

Item	Most	High	Moderate	Low	Mean ($\bar{x}$)	S.D.	Interpretation
1. Utility	7	3	-	—	4.02	0.21	High
2. Appropriateness of Materials	8	2	—	—	4.11	0.17	High
3. Color Groups of Textiles	8	2	-	-	4.11	0.25	High
4. Textile Patterns	8	2	—	—	4.8	0.24	High
5. Fineness and Aesthetic Quality	8	2	—	—	4.51	0.12	Highest
6. The use of antibacterial agents on clothing	8	2	—	—	4.16	0.32	High
7. Suitability for use	9	1	-	—	4.13	0.27	High
8. Antibacterial Textile Innovation	10	-	-	—	4.76	0.32	Highest
9. Identity of local handwoven brocade Lamphun textile	7	2	1	—	4.56	0.17	Highest
10. Appropriateness to Current Context	9	1	—	—	4.65	0.23	Highest
Overall	—	—	—	—	4.38	0.29	High

(Source: Jaipak Burapajatana, 2025)

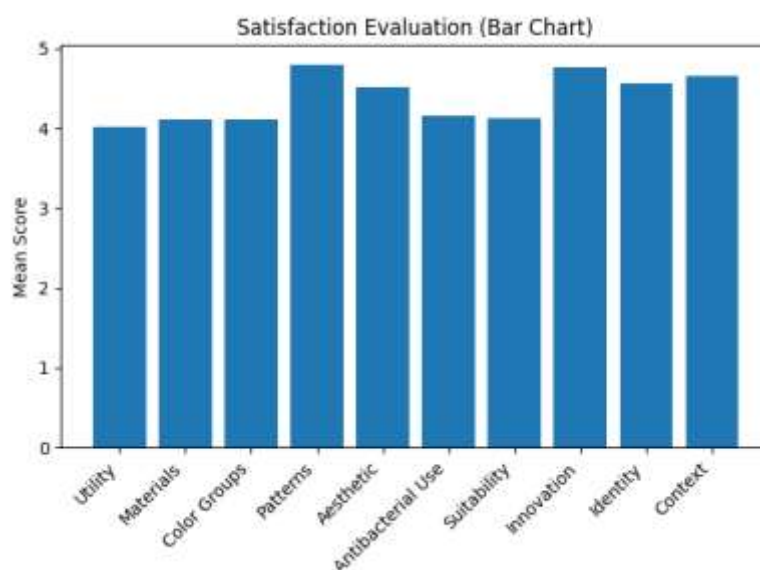


Figure 10. The chart shows results of evaluation of experienced Lamphun hand weavers' satisfaction with antibacterial properties of local handwoven brocade Lamphun textile.

(Source: Jaipak Burapajatana, 2025)

Result of satisfaction of 10 sample hand-weavers can be summarized as follows:

Result of evaluation for satisfaction of experience hand-weavers of Lamphun for antibacterial properties of the sample product at average 4.38 and 0.29 revealed that weavers satisfied with those sample products.

In perspective consideration, the most aspect satisfactory was from antibacterial innovation ($\bar{x} = 4.76$), suitability for current context ($\bar{x} = 4.65$), reflect of identity of Lamphun brocade ($\bar{x} = 4.56$) and refinement with artistic value ($\bar{x} = 4.51$). The obtained data reflect importance of textiles innovation, artistic value and preserve of local identity.

High score which obtained from other aspects, such as their usage, color, textile patterns and textile designs suggests that the textile is suitable for both production and development.

Discussion

This research demonstrates that integrating wisdom in traditional Lamphun hand-woven brocade with modern textile materials science can efficiently enhance function of local hand-woven fabric and not compromise its cultural value and aesthetic appearance. Usage of Quat Silane micro particle antibacterial coating with fabric shows significantly improvement technique in antibacterial property of fabric. This consistent with previous studies that potential of technology able to enhance hygienic property of natural textiles.

This research indicates that the process of applying antibacterial treatment on surface of the fabric do not affect texture, tactile property or visual identity of traditional weaving of Lamphun brocade. It shows that traditional hand-woven fabrics which are significant in culture can be enhance with technology while still preserving their original uniqueness, and could solve be applied for improving the heritage craftsmanship. In addition, the result of this research suggests that innovation and tradition can be harmoniously coexist (Zafri et al., 2023).

The prototype of innovative Lamphun hand-woven fabrics which has been developed demonstrates possibility of applying scientific innovation with community production level and enhancing capability of artisan and their product value. The outcome aligns with the principle of sustainable development by promoting cultural continuity, and innovative of fabric finishing technique able to add new function

to them to serve demand of the market and consumers who prefer traditional hand-woven fabrics (Pansuwong et al., 2023).

Suggestions

Innovation research of textile, for example, fiber production technology or nanomaterials that used for fabric finishing, have been studying and developing to improve function of the fabrics in order to serve requirement of consumers. Enhancing property to traditional hand-woven fabrics will result in fostering of original local hand-woven textiles products and add new function of usage to them.

Acknowledgement

The researchers would like to express their gratitude for support in technology advancement project and research promotion fund from Rajamangala University of Technology Thanyaburi that enable the successful completion of this research. The researchers would also express their gratitude to Lamphun brocade weaving community, the expert brocade-weavers of Lamphun province, and Hariphunchai Handwoven Textile Institute for their valuable knowledge and expertise and participated in the fabric production project which is an important of this research. The findings from this research not only benefit in terms of academic but also become guidelines for increasing commercial value and preserving wisdoms in production of traditional brocade fabrics of Lamphun province which is a national heritage of Thailand.

References

1. Bangbon, P., Kanchanathaveekul, K., Thoy, U., Siribensanont, C., Channuwong, S., & Jia, Y. (2026). Generative AI and entrepreneurial psychological capital for sustainable SME performance: The roles of hope, resilience, and adaptive behavior in emerging economies according to SDG 3 (Good Health and Well-being). *Journal of Intelligent Decision Making and Information Science*, 3(4s), 166-186. <https://doi.org/10.59543/jidmis.v3.1002>
2. Channuwong, S., Thongnun, W., Lamyai, W., & Jia, Y. (2026). AI-Driven digital innovation in agricultural and biological sciences education: A structural analysis of knowledge transfer, student engagement and learning effectiveness toward SDG 4 (Quality Education) in Thai universities. *Natural and Engineering Sciences*, 11(3), 276-290. <https://doi.org/10.28978/nesciences.263024>
3. Chen, K. N., & Li, J. Y. (2024). Advances in antibacterial textile coatings based on organosilane micro-particles. *Journal of Textile Science and Engineering*, 18(4), 215-228.
4. Fei, Z., Channuwong, S., Bangbon, P., Siripap, P., & Jia, Y. (2026). Socioeconomic and adaptive determinants of sustainable agricultural development (SDG 2) in Thailand. *Natural and Engineering Sciences*, 11(2), 140-152. <https://doi.org/10.28978/nesciences.262012>
5. Kongprasert, P. (2021). Cultural symbolism in Lamphun brocade weaving patterns. *Journal of Thai Art and Culture Studies*, 12(3), 45-59.
6. Li, J. Y., & Chen, W. L. (2022). Durability of Quat Silane antibacterial coatings on natural fibers. *Textile Chemistry and Applications*, 15(1), 89-97. <https://scholar.google.com/scholar?q=Durability+of+Quat+Silane+antibacterial+coatings+on+natural+fibers>.
7. Pansuwong, W., Photchanachan, S., & Thechatakerng, P. (2023). Social innovation: Relationships with social and human capitals, entrepreneurial competencies and growth of social enterprises in a developing country context. *Social Enterprise Journal*, 19(1), 51-79. <https://doi.org/10.1108/SEJ-02-2022-0014>
8. Phasuk, N., Bangbon, P., Channuwong, S., Jia, Y., Nindya Saraswati, N. (2026). Risk management effectiveness and sustainable development in the insurance industry: Decent work and economic growth (SDG 8). *Acta Innovations*, 61, 707-723.
9. Satchasomboon, S., & Techatekeng, P. (2016). Strategies for differentiating 5-star OTOP fabric products (brocade silk) of entrepreneurs in Lamphun Province. *Far Eastern University Academic Journal*, 10(3). <https://so01.tci-thaijo.org/index.php/FEU/article/view/48605>
10. Shao, H., Jin, Q., Guo, Y., Zhou, F., Wider, W., & Lu, L. (2025). The relationship between the structure of firms' human capital and corporate innovation performance. *PLOS ONE*, 20(4), e0321388. <https://doi.org/10.1371/journal.pone.0321388>

11. Thammaprasert, J. (2021). Sustainability and cultural resilience in Thai textile communities. *Asian Journal of Arts and Sustainable Design*, 11(4), 177–192.
<https://scholar.google.com/scholar?q=Sustainability+and+cultural+resilience+in+Thai+textile+communities>
12. Thimakham T. (2015). Creation of Local Wisdom Information Media: Cotton Brocade Weaving of Lamphun Province. *Community and Social Development Journal*, 16(1), 99–121.
<https://doi.org/10.14456/rcmrj.2015.215106>
13. UNESCO. (2020). *Safeguarding intangible cultural heritage through innovation and creative industries*. UNESCO Publishing. <https://unesdoc.unesco.org/>
14. Wang, Y., Lin, D., & Zhao, H. (2023). Performance of Quat Silane micro-particle antibacterial coatings under repeated washing. *Advanced Functional Textiles*, 14(6), 351–362.
<https://scholar.google.com/scholar?q=Performance+of+Quat+Silane+microparticle+antibacterial+coatings+under+repeated+washing>
15. Wong, C.H., Kumar, S., Ramli, S., Madhavedi, S. (2025). Factors influencing customer behavior in impulse buying of cosmetics on live shopping platforms in Malaysia. *Humanities and Social Sciences Letter*, 13(1), 270-284. DOI: <https://doi.org/10.18488/73.v13i1.4094>
16. Yayah, I. N., Supeni, R. E., & Suharsono, R. S. (2025). The influence of e-marketing and product quality on purchase decisions with brand awareness as an intervening variable in Wardah skincare products in Jember. *International Journal of Multidisciplinary Sciences and Arts*, 4(4). October. P. 248–253. <https://doi.org/10.47709/ijmdsa.v4i4.7055>
17. Zafri, K.Z., Sigdel, B., & Bhandari, P. (2023). Crisis management during the COVID-19 pandemic: Street food vendors' perspectives from Bangkok. *Journal of Contingencies and Crisis Management*, 31(4), 877-889. <https://doi.org/10.1111/1468-5973.12488>
18. Youthao, S., Channuwong, S., Weerachareonchai, P., Dhammahansakul, N., Sun, R., & Jia, Y. (2026). An AI-Driven framework for smart micro-housing and sustainable urban development (SDG 11). *Natural and Engineering Sciences*, 11(2), 242-252. <https://doi.org/10.28978/nesciences.262022>
19. Zhang, L., Chen, X., & Yu, H. (2021). Antibacterial surface modification of textiles: Current trends and future prospects. *Materials Chemistry Frontiers*, 5(8), 3210–3224.