The 13th International Conference on
Materials Science and Technology
MSAT

Innovations in Fibrous Biomass Valorization

From agricultural residues to high-value sustainable materials

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MSAT 2026 | 12 November 2026

The 4th Symposium on Innovation and Sustainability: Biomass and Biochar Utilization in the ASEAN Context



Where is KAPI, KU?

KAPI consists of four main buildings:

1 Main Administration and Research Building

- Teera Sutabutra Building serves as the main office and coordination center at the 2ˊˊ floor.
- Other Laboratories and facilities for research and development from 1-8ˊ floor.

2 Agro-Industry Building 3

- 7ˊˊ Floor for rubber and polymer technology laboratory.
- 8ˊˊ Floor for starch, rice and sugar laboratory.

Pilot Plants

1.1 Natural Fiber Preparation

- ❑ for Packaging includes equipment such as a pulping unit, steam explosion system, pulp molding for pilot scales.
- ❑ for textile fiber with ring spinning laboratory to be yarn production.

1.2 Flavor Extraction and Manufacturing Plant

2 Building of Advanced Plant Production with Artificial Light

for application of advanced technology to control plant growth.
production of bioactive compounds, as well as technology for extracting key substances.
"K-AP1" start-Up company jointed under KAPI, KU.

1 Teera Sutabutra building



2 Agro-Industry Building 3





www.kapi.ku.ac.th

Our Expertise

KU KASETSART UNIVERSITY | KAPI | TEXTILE & SCIENCE AGRO-INDUSTRY

1. SRU of Plant production technology and Biomass Management

- **Breeding and screening** suitable fast-growing tree for energy
- **Technology development** for certified wood chip and wood pellet production
- **Management of energy forest park** for community power plant
- **Analysis service** for energy raw materials according to ISO17025
- **Technology transfer** to public and private sectors

Biomass Products



Rice straw and rice husk pellet and briquette



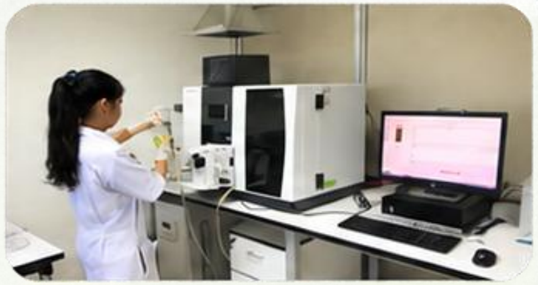
Produce Acacia Hybrid seedlings



Promote fast growing trees planting as energy forest park



Monitoring factors influencing fast growing trees planting



Biomass heat value analysis laboratory (SO17025)

Our Expertise

2 Special Research Unit in Healthcare Products and Cosmetic

- **Screening** of bioactive compounds from various biological sources i.e. agricultural products and by-products, local plants and herbs, microorganisms.
- **Enhancing** bioactive compound production in plant using artificial light technology and in microorganisms.
- **Improving** bioactive compound extraction efficiency and developing green extraction technology.
- **Characterization** of bioactive compound chemical structure and developing non-destructive quantification method using Near Infrared Spectroscopy (NIR).
- **Study** the biological activity of bioactive compound related to healthcare products and cosmetic applications.
- **Application** of nanotechnology to improve stability and efficacy of bioactive compounds.



Our Expertise

KU KASETSART UNIVERSITY | KAPI | TEXTILE & SCIENCE AGRO-INDUSTRY

3 Special Research Unit in Bio-based Polymer and Composite Technology

Exploring potential biopolymer sources
i.e. plants, animals, insects, microorganisms, agricultural by-products, industrial wastes i.e. clothes, natural sources i.e. marine wastes.

Understanding biopolymer structure and quality
through characterization of their chemical and physical properties.

Inventing functional biopolymers and composites
through transforming technology.

Fabricating prototypes from biopolymers and composites
in order to promote the new material to reduce synthetic polymer usage.

Biopolymer Sources



From Bio-resources to Materials



Biopolymer & Composite Applications



Agenda

01 Fibrous Biomass in the Circular Bioeconomy

02 Research Innovations and KAPI and Collaborative Case Studies

03 Emerging Technologies and Industrial Challenges

04 Sustainability and Future Perspectives

05 Question and Discussion

Research Landscape: From Fibers to Function

Natural fiber research (2021–2026): from agricultural residues to high-value functional products

FEEDSTOCKS



LEAF
Pineapple
Banana



STEM
Hemp
Flax • Jute



RESIDUES
Rice straw
Coir

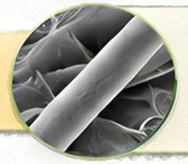
PROCESSING & ENGINEERING

01



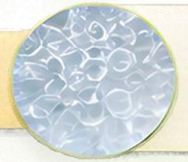
GREEN EXTRACTION
Mechanical • Enzymatic • Low-chemical

02



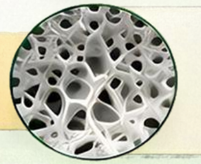
FIBER ENGINEERING
Cottonization • Blending • Surface treatment

03



ADVANCED MATERIALS
Nanocellulose • Hybridization • Bio-binders

04



PERFORMANCE DESIGN
Structure • Interfaces • Durability

FUNCTIONAL PRODUCTS



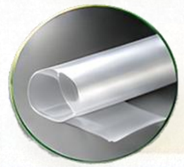
YARNS & TEXTILES
Spun yarns • Blended fabrics



FUNCTIONAL NONWOVENS
Absorbents • Filters • Insulation



BIOCOMPOSITES
Panels • Automotive • Construction



BIO-BASED FILMS
Nanocellulose • Packaging

RESEARCH FRONTIER

- Scale-up
- Fiber quality standardization
- Moisture resistance
- CO_2 LCA / carbon footprint

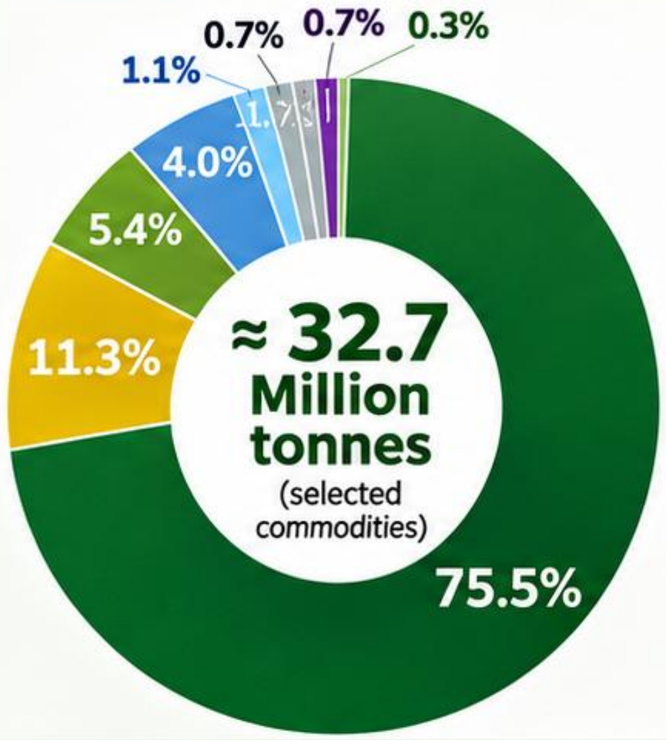
Mateo et al. (2021), Processes 9, 1594. DOI: 10.3390/pr9091594 | Nagaraja et al. (2024), RSC Adv. DOI: 10.1039/D4RA00149D
Mijas et al. (2025), Cellulose 32, 5147–5166. DOI: 10.1007/s10570-025-06557-0

Global Natural Fiber Production | FAOSTAT Data

Reported production by commodity (latest verified years: 2023–2024)

Production of Selected Plant Fiber Commodities

(FAOSTAT; mixed 2023–2024 data)



Commodity (Year)	Production (million tonnes)
Cotton lint (2023)	24.70
Jute (2024)	3.70
Coir (2024)	1.773
Flax (2024)	1.293
Hemp (2024)	0.369
Sisal (2024)	0.234
Kenaf & other bast fibers (2024)	0.230
Abaca (2024)	0.109

SILK | *different production stage*



0.464 million tonnes
Reelable silkworm cocoons
(NOT raw silk), FAOSTAT 2024



93,988 tonnes | 2023
Raw silk (not thrown)
Different product from cocoons; not comparable to plant fibers.

Emerging agricultural-residue fibers





Production volumes not separately reported by FAOSTAT; potential for value-added materials.

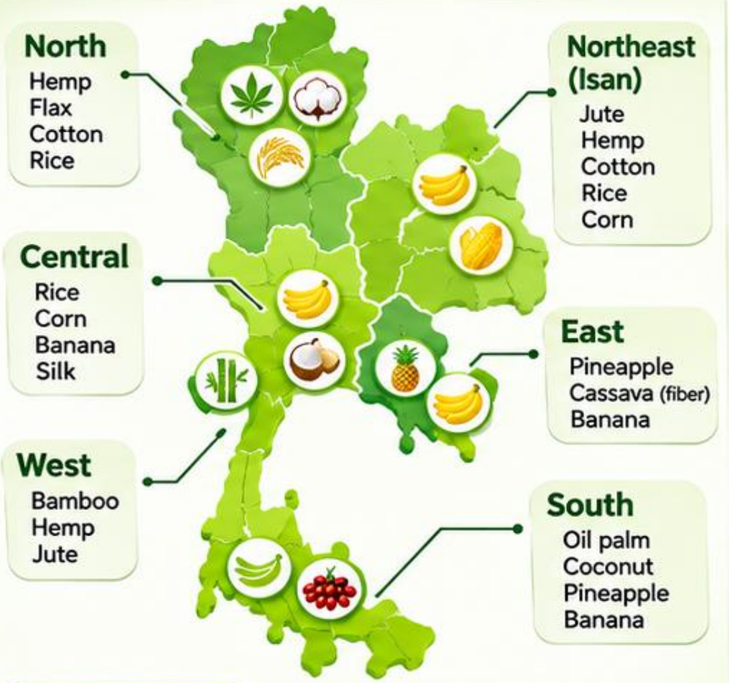
Illustrative shares among selected commodities; mixed 2023–2024 data; not an FAO global natural-fiber market-share estimate.

Source: FAOSTAT, Crops and Livestock Products (cotton lint: 2023; jute, coir, flax, hemp, sisal, kenaf & other bast fibers, abaca: 2024).
Note: Values are rounded; FAOSTAT does not report extracted pineapple-leaf or banana-pseudostem fiber production.

Key Natural Fiber Resources in Thailand

Major bioresources, cultivation areas, and research opportunities for sustainable materials

Thailand: Major Cultivation Areas of Natural Fiber Resources*



Resource icons

Pineapple, Coconut, Oil palm, Banana, Silk (B. mori / Eri), Hemp, Cotton, Bamboo, Corn, Rice, Jute, Flax

*Approximate main cultivation areas in Thailand, based on national agricultural data and research reports (e.g., OAE, DOA, OCSB) and KAPI research surveys.



Pineapple *(Ananas comosus)*

Leaf fiber – strong, lightweight, value-added textiles & composites.



Coconut *(Cocos nucifera)*

Coir fiber – high toughness, durable, for composites, geotextiles & mattresses.



Oil Palm *(Elaeis guineensis)*

Frond/empty fruit bunch fiber – abundant, for composites & molded products.



Banana *(Musa spp.)*

Pseudo-stem fiber – good strength and fineness, for textiles, nonwovens & biocomposites.



Silk *(Bombyx mori / Samia ricini)*

Protein fiber **(fibroin/sericin)** – for textiles, biomedical and functional materials.



Cotton *(Gossypium spp.)*

Seed-hair fiber – soft, breathable, for apparel and medical textiles.



Hemp *(Cannabis sativa L.)*

Bast fiber – high strength and stiffness, for textiles, biocomposites & insulation.



Bamboo *(Bambusa spp.)*

Bast fiber – high strength, renewable, for textiles, panels & construction materials.



Jute *(Corchorus spp.)*

Bast fiber – good tensile strength, for sacks, geotextiles & composites.



Flax *(Linum usitatissimum L.)*

Bast fiber – fine, strong and breathable, for high-value textiles & biocomposites.



Corn *(Zea mays L.)*

Husk fiber – lightweight, biodegradable, for nonwovens, packaging & composites.

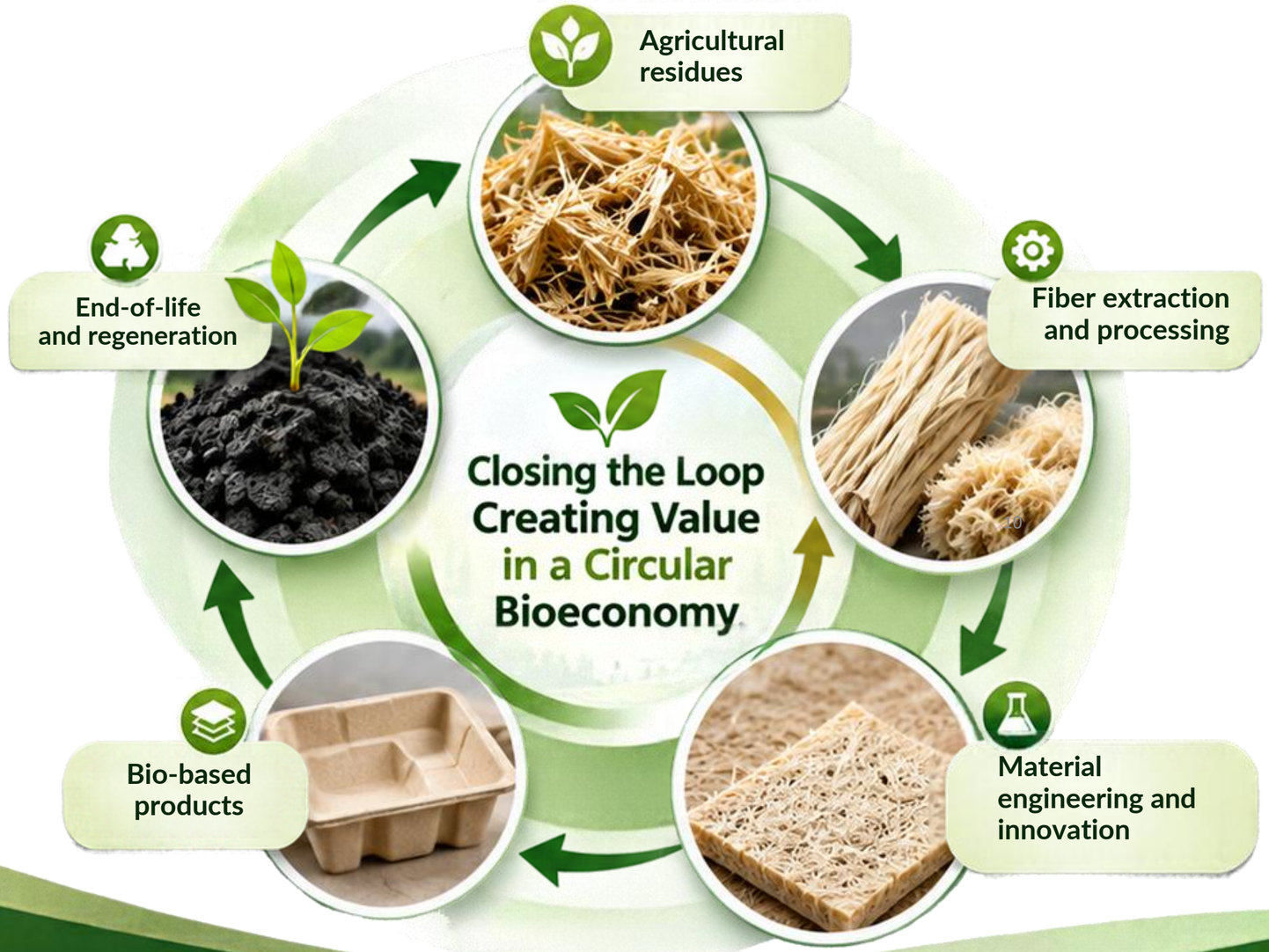


Rice *(Oryza sativa L.)*

Rice straw fiber – abundant, low-cost, for panels, biocomposites & insulation.

Why Fibrous Biomass Valorization Matters

Resource efficiency • Residue management • Material substitution



- Agricultural residues are **renewable,** regionally available feedstocks.
- Open burning and underutilization create **environmental pressures.**
- Fiber valorization **complements** energy and biochar pathways.
- Priority: match biomass quality to the **highest feasible value chain.**

Research & Academic Partners

มหาวิทยาลัยผหิ
คล
คณะวิทยาละร

National Funding & Support Agencies

กระทรวงการอุตเฟิร์คมา
วิทยากาลกรี วิธีเล่นเบวัต
กรรม

R&D and Innovation Partners

บหาวิทยาลัย
ต่างเล่าเฟรโนกรี

Industrial & Commercial Partners

ERWAN TEXTILE CO.,LTD.
บริษัท เธทวีทเส้นกอ จำกัด

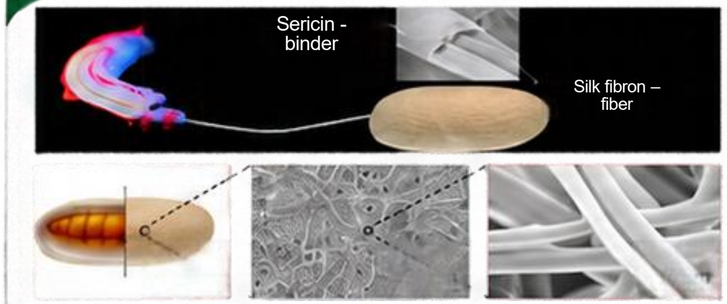
Natural Fiber Research of KAPI

Rungsima Chollakup et al.

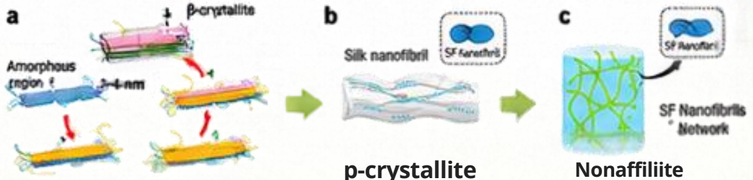
Kasetart Agricultural and Agro-Industrial Product Institute
Department of Textile Science, Faculty of Agro-Industry
Kasetart University



Protein fiber (silk)



(Shah, Protein Polym. Polymers, 2015)



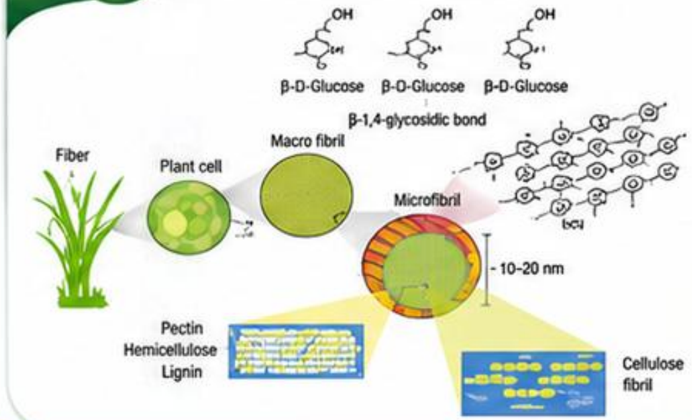
Main Components

- **Fibron : fiber, film, food**
- **Bonding - moisture-retaining coating**

Forms of Fiber Utilization

Paper
Composites / Films
Textiles

Cellulosic fiber



Main Components

- **Cellulose** : fiber, food, nano-derivatives
- **Hemicellulose** : paper, furfural, ethanol
- **Lignin** : adhesives, batteries, additives, wastewater treatment, added to cement tiles, **antimicrobial agents**

Fiber Applications

	Nonwovens		Blends with thermosetting plastics	Blends with thermoplastics	Pulping	Pulverisation
textile processing			BMC/RTM	Extrusion		
Bonding rolling				Granulate		
+ Polymers + UPEs, époude PR	+Binder + Fiber	+ Thermosets + Fiber + stacking + Additives	Molding Pultrusion	Molding		
Leisure/sport industry (cycle frames, surfboard, fishing rods) Fiction lining (blended yarns from metal, aramid, cellulosic fibers)	Insulation Filing Packaging material	Molded articles Automotive interior parts Furniture	Molded articles Cages Automotive parts body parts)	Molded articles Fails Profiles	Paper bonds bags special papers)	Filling agents concrete polymers food varnish paints
Max. fiber length	**4–100 mm**	**4–100 mm**	**5–25 mm**	**<5 mm**	**1–5 mm**	**ca. 1 mm**

Fiber length

Extraction Processes

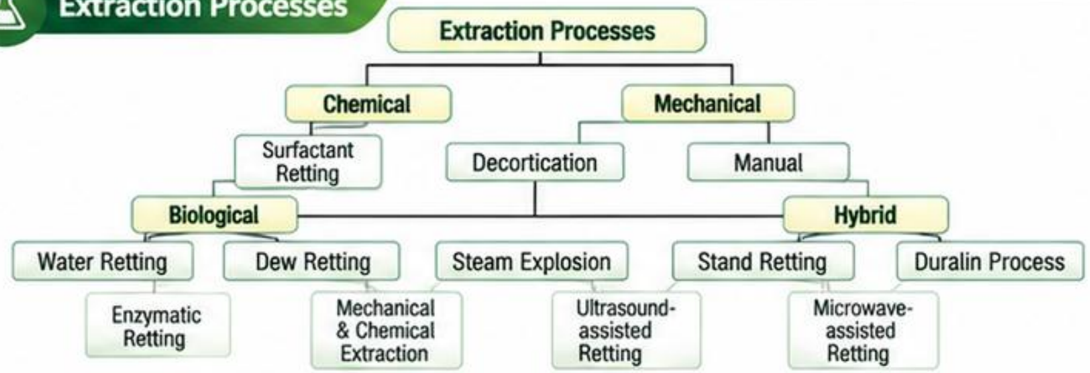


Figure 3. *Classification of natural fiber extraction methods by process type.*

Pineapple Leaf Fiber: Mechanized Extraction

KAPI research: automatic decortication and scalable fiber preparation

Sustainable textile & fashion products made from pineapple leaf waste

1 Pineapple Farm



2 Leaf Harvest & Pineapple Leaf Collection



3 Extracting & Processing Pineapple Leaf Fiber (PALF)



In order to reduce environmental damage, the adoption of sustainable practices has now become a pre-requisite across multi-industries.



600M-800M tonnes of agricultural waste generation in Southeast Asia annually (e.g. empty fruit bunch, rice straw, bagasse)



10,000+ types of waste is needed to produce a cotton shirt and a pair of denim jeans



~2B tonnes of carbon dioxide is emitted annually from damaged peatlands for human activities such as gardening & biofuel



Plantation area (rai)

- > 30,000
- 10,001 – 30,000
- ≤ 10,000
- No plantation area



Key Takeaways

- Pineapple leaf residues as a cellulose-rich resource
- Mechanical extraction and fiber opening
- Enabling yarn, packaging and nonwoven applications

Source: KAPI MSAT original presentation, 2026 | KAPI case studies

Pineapple Residues to Regenerated Cellulose

Preparation of dissolved pulp pineapple leaf fibers

Dissolving pulp and dry-jet-wet spinning for lyocell development



PALF from Ratchaburi province was prepared using decorticating machine (supported by company)





Alkaline pulping
Sodium hydroxide (NaOH)
Potassium hydroxide (KOH)







Dissolving pulp



Bleaching
- Chlorine dioxide
- Hydrogenperoxide



Lyocell fiber forming by dry-jet-wet spinning

Dissolving pulp → (Add NMMO 100 °C, 1 h) → Swollen dissolving pulp → (Add more NMMO 100 °C, 3 h) → Cellulose dope → (Dry-jet-wet spinning) → Lyocell fiber

Cellulose dope →



Fiber Properties

Properties	PALF after Alkaline pulping with 5ⁿ bleaching	Wood pulp (Jiang et al., 2020)
Brightness (%)	83.26 ± 0.31	
Alpha-cellulose (%)	91.99 ± 0.44	
Intrinsic viscosity (mL/g)	452.70 ± 6.58	280 ~ 350
DP (ASTM D1795-13)	913.37 ± 14.74	650 ~ 750

- Microscopy and SEM / FTIR
- XRD TGA
- Density Shrinkage
- Tensile properties
- Dye absorption



Corn Stalks to Thermal Insulation

From corn stalks to fiber





Corn stalks from Nan, Chiang Rai, to burning emission




Fiber extraction at Doi Tung, Chiang Rai and Collaborative CSP, Chian Mai

Key Process Highlights

- Corn stalk fiber preparation and conditioning
- Nonwoven processing with recycled PET components
- Insulation roll prototype: 50 kg/m²; 2.5 cm thickness

Nonwoven processing & insulation formation



1 Fiber mixing (with recycled PET)



2 Blending & opening



3 Fiber web forming



4 Web consolidation (Thermal bonding)



5 Web transfer



6 Thickness control



7 Nonwoven sheet



8 Final product (Insulation roll)



Maizulation



TGDA2025 prize (Resources Efficiency)



Source: KAPI MSAT original presentation, 2026 | KAPI case studies

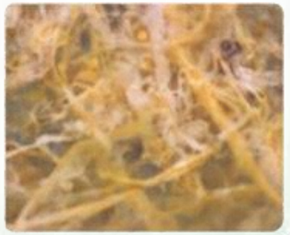
Rice Straw: Circular Material Valorization

Transforming agricultural residues into usable fiber-based materials

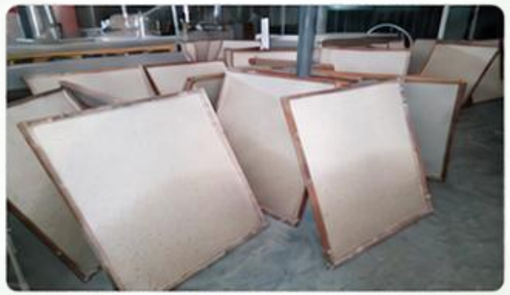
Rice Straw (Raw Material)







Pulp & Fiber Processing





Value-added Products







SPECIALTY PAPER PRODUCTION FROM RICE STRAW

- Paper made from rice straw with high strength and unique properties
- Very suitable for the healthy an sustainable paper industry
- More renewable and safe raw materials
- Can be used in all fiber-paper for food and various paper for the green economy



Applications

Food packaging | Tableware | Fiber products | Textiles | Daily products



Key Outcomes

- Rice straw fiber production
- Development of fiber composites
- Specialty paper technology
- Textile and value-added products



WāēñunīvynŚeqúvrrw (Bio-based products) จากฟางข้าว

Circular Benefits

- Upcycling of agricultural waste
- Reducing plastic use
- Creating sustainable, high-value biobased materials

Source: KAPI MSAT original presentation, 2026 | KAPI case studies

Hemp: From Stem to Technical Textile

Fiber processing and product development across the value chain

Hemp Fiber Value Chain

1 Fiber Extraction & Conditionin





2 Fiber Refinement & Textile Processing





3 Yarn, Nonwovens & Composites



Applications





4 Packaging from hurd



Key Activities

- Bast fiber extraction and conditioning
- Fiber refinement and textile processing
- Prospects for yarns, nonwovens and composites

Key Outcomes

- High-quality hemp bast fiber
- Textile and nonwoven prototypes
- Composite materials for insulation and building applications

Source: KAPI MSAT original presentation, 2026 | KAPI case studies

Bamboo: Steam Explosion Fiber Processing

Steam-assisted technology for natural bamboo fiber recovery

Process Flow: From Bamboo to Value-added Products

1 Bamboo Raw Material





2 Steam Explosion Pre-treatment



Steam explosion
(high-pressure steam)

3 Fiber Recovery



4 Fiber Processing & Product Forms

















Porous carbon

5 Value-added Products





















Key Activities

- Steam explosion pilot processing (100 kg equipment shown)
- Fiber recovery and opening for textile use
- Co-product opportunities: fuel and porous carbon

Outcomes & Applications

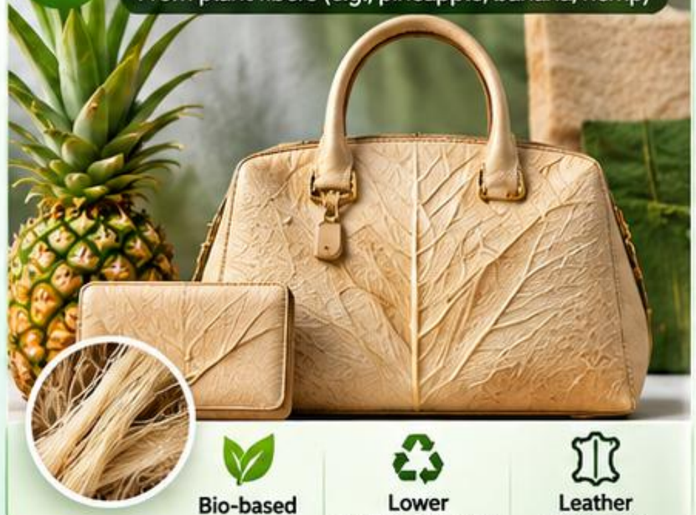
- Natural fiber for textiles
- Nonwoven / composite materials
- Co-products: Fuel and porous carbon

High-Value Applications from Natural Fibers

Turning agricultural fibers into sustainable materials for diverse industries

1 Bio-leather (Bio-based Leather)

From plant fibers (e.g., pineapple, banana, hemp)



- Bio-based
- Lower carbon footprint
- Leather alternative

2 Smart Bio-Packaging

Biodegradable and 100% tracable



- Biodegradable
- Food-safe option
- Lightweight & strong

3 Automotive Components

Lightweight and high-strength composites for EV and sustainable mobility



- Lightweight
- High strength
- Suitable for EV

Key Benefits

- **Valorize** agricultural residues
- **Reduce** environmental impact
- **Create** high-value products

4 Acoustic & Thermal Panels

Sound and heat insulation for green buildings



- Noise reduction
- Thermal insulation
- Green building

5 Medical Biomaterials

High-performance materials from silk (sericin/fibroin)



- Biocompatible
- Safe & non-toxic
- Biomedical applications (e.g., wound dressing)



Valorization of Sugarcane Residues

From the Sugar Industry to High-Value Bio-Based Materials





Sugarcane Residues from the Sugar Industry





Bagasse
(post-sugar extraction)



Sugarcane leaves
(field residue)

Beyond Energy: High-Value Utilization

- **Nanocellulose** (from bagasse)
- **Natural fibers** (from sugarcane leaves)
- **Bio-based materials** (Textiles, composites, and more)

Process & Technology



Bagasse → Nanocellulose (CNF/CNC)

Pretreatment (Cleaning & Pulping) › Nanosizing (Mechanical/Chemical) › Nanocellulose (CNF/CNC)



Sugarcane leaves → Natural fibers

Mechanical decortication › Cleaning & Refining › Cellulosic fibers (textile grade)





pplications



textiles
(yarn, fabric)

posites
(boards, panels, packaging)



Functional materials
(e.g., films, hydrogels)

Key Benefits (Circular Bioeconomy)

- Higher value from agri-residues
- Diversification beyond energy
- Lower environmental impact
- Income opportunities for local communities
- Toward a zero-waste sugar industry

Emerging Biomass: Beyond Conventional Fibers

New and unconventional biomass for next-generation sustainable materials

Durian Peel





Cellulose-rich pulp from durian peel for regenerated fibers and bio-based materials

Macroalgae





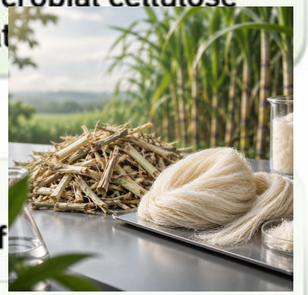
Novel yarn blends and bio-based materials from macroalgae

Microbial Cellulose & Mycelium





Grown materials from microbial cellulose and mycelium (biofabricat



Case Study: Durian Peel to Sustainable Lyocell Fibers

Pulp Preparation



- Durian peel
- Chemical pulping
- Bleaching

Lyocell Spinning



- Pulp solution
- Controlled composition
- Wet spinning (Lyecell)

Fiber Evaluation



- Mechanical properties
- Morphology
- Dyeability and function

Performance & Upcycling



- Thermal and dye stability
- Durability
- Upcycling to textile products

Research Opportunities

- Characterization and processing of
- Development of functional and high-value materials (e.g., textiles, composites, films)
- Scale-up and life cycle sustainability assessment (e.g., circular and low-carbon systems)

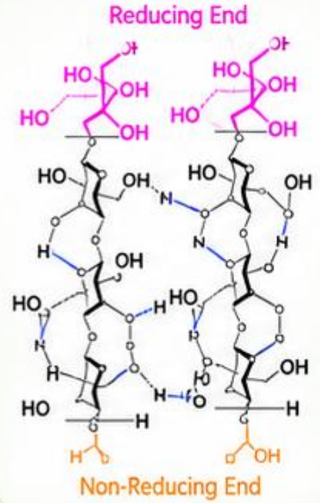
Note: Research opportunities — not all are established KAPI products.

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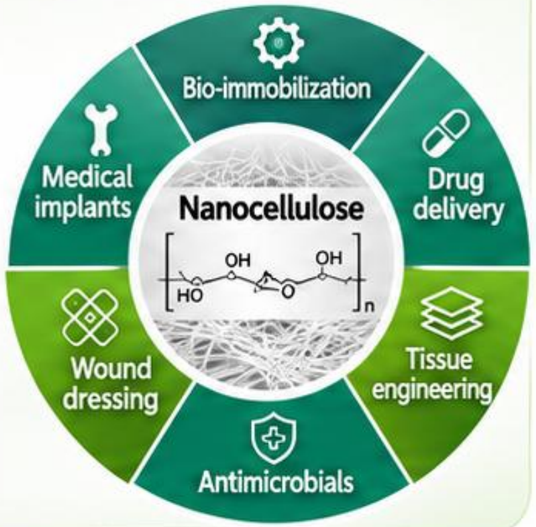
Biomedical Applications of Sustainable Cellulose Nanocrystal-Incorporated Hydrogels

From plant biomass to functional hydrogels for next-generation healthcare

(a) Cellulose structure



(b) Nanocellulose platform



From Plant Biomass to CNC and Hydrogel



Key Applications

- Nanocellulose
- Energy storage material
- Flexible electronics
- Optoelectronic materials
- Smart biomaterials
- Biosensors

Cellulose Sources (Sustainable & Renewable)



Conversion to Cellulose Nanocrystals (CNC)

Sulfuric acid hydrolysis → Oxidation → Mechanical agitation → Chemical modification & functionalisation

CNC-incorporated Hydrogel



Biomedical Applications



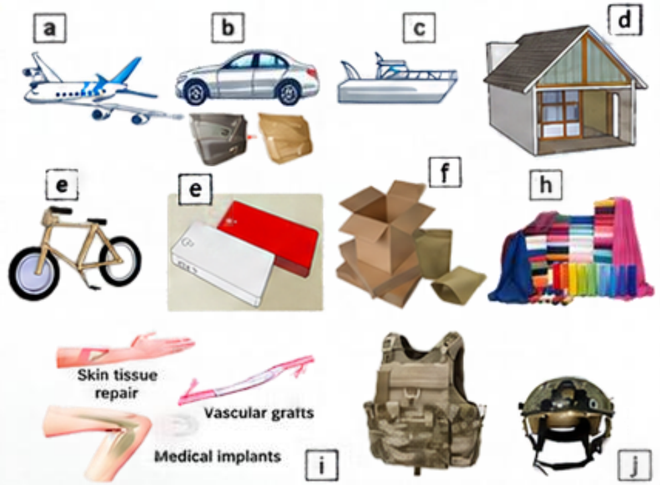
Future Research Roadmap | 2026–2035

Proposed directions for academia–industry collaboration

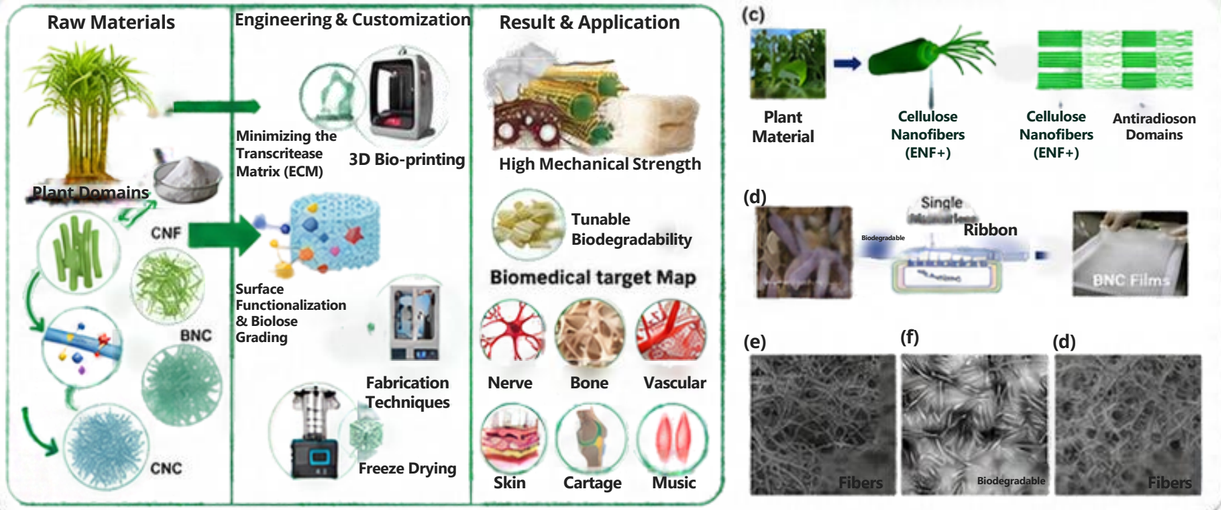
Key Application Prototypes



Target Applications & End-Use Markets



Sustainable Nanocellulose Scaffolds for Tissue Engineering



Research Roadmap (2026–2035)

2026 – 2028



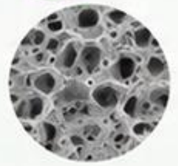
Green extraction & pilot-scale fiber quality

2029 – 2031



Functional nonwovens & hybrid biocomposites

2032 – 2035



Smart biomaterials, scale-up and circular systems

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Thank You
ขอบคุณค่ะ



Questions & Discussion
คำถามและแลกเปลี่ยนความคิดเห็น



From Agri-Residues | to High-Value Bio-Materials | for a Circular Bioeconomy