IPPTA
Indian Pulp & Paper Technical Association

cftri
Giving Food a Future

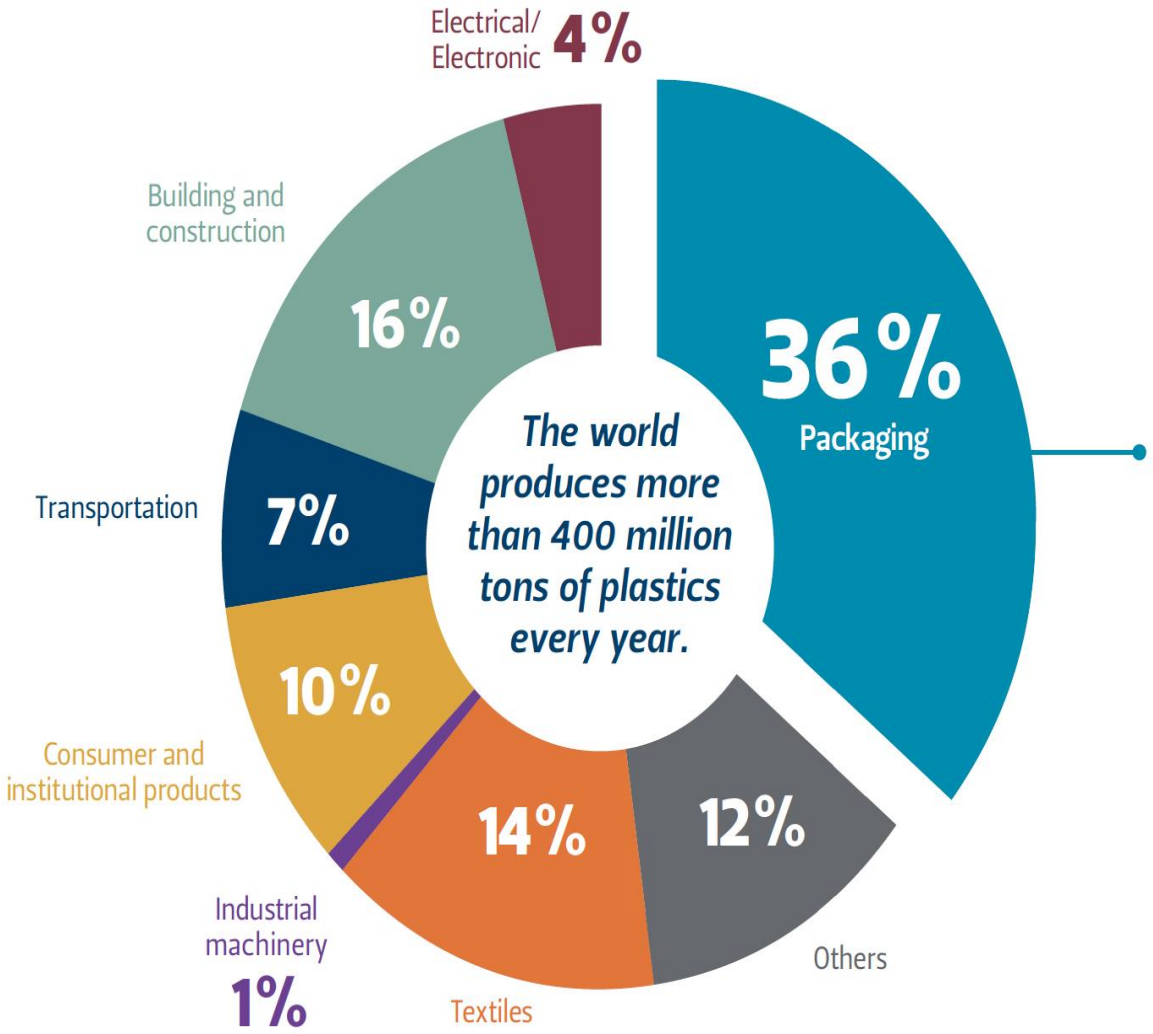
Latest Research & Developments in the Area of Paper as Packaging Material for Food Applications

Presented by

Prof. Kirtiraj K. Gaikwad, PhD, FLS
Assistant Professor
Indian Institute of Technology Roorkee

Department of Paper Technology, IIT Roorkee, Saharanpur campus

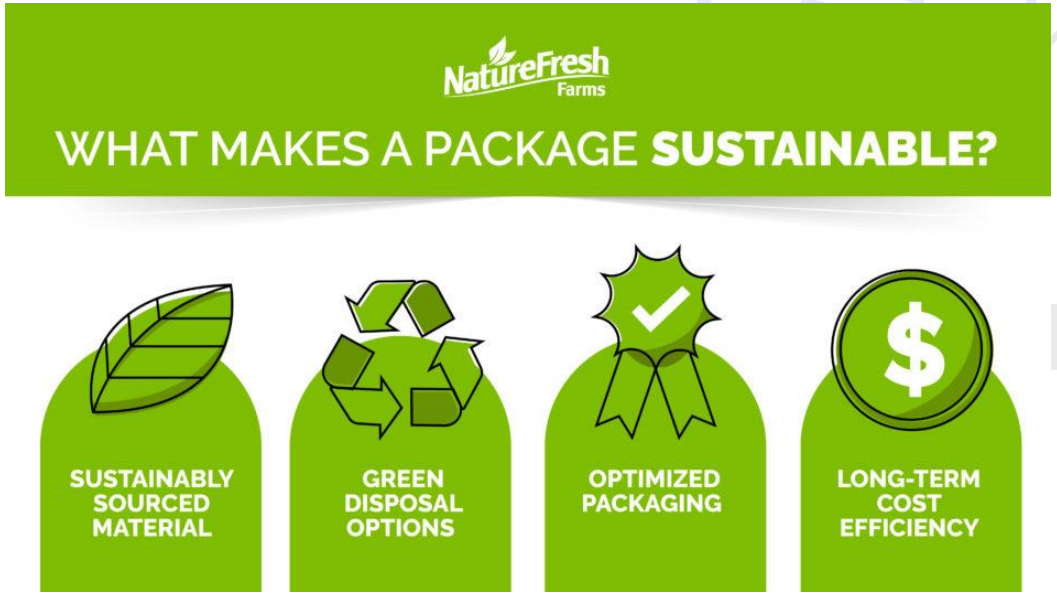
Introduction



The largest contributor to the plastic waste problem is **single-use plastic** packaging designed for immediate disposal

https://www.bakerinstitute.org/research/plastic-waste-and-sustainability

Introduction



- Two-thirds (67%) of consumers consider it important that the products they buy are in recyclable packaging,
- More than half (54%) take sustainable packaging into consideration when selecting a product.
- Younger consumers — those 44 years and younger — are leading the charge, with 83% reporting that they are willing to pay more for it, compared to 70% of all consumers.

Trivium Packaging's 2021 Global Buying Green Report.

Paper Packaging Trends

Single Serve Packs

Reduction in costs & volumes

Smart Packaging

Anti-counterfeit Pack

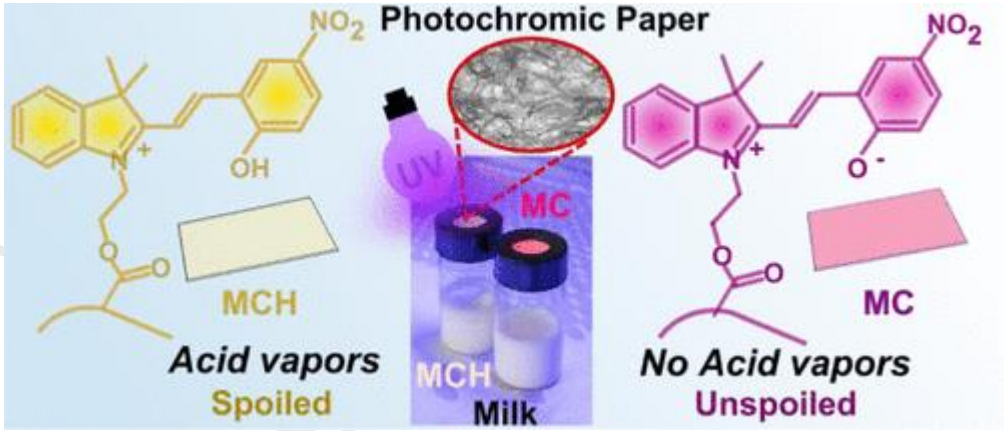
Printing Techniques

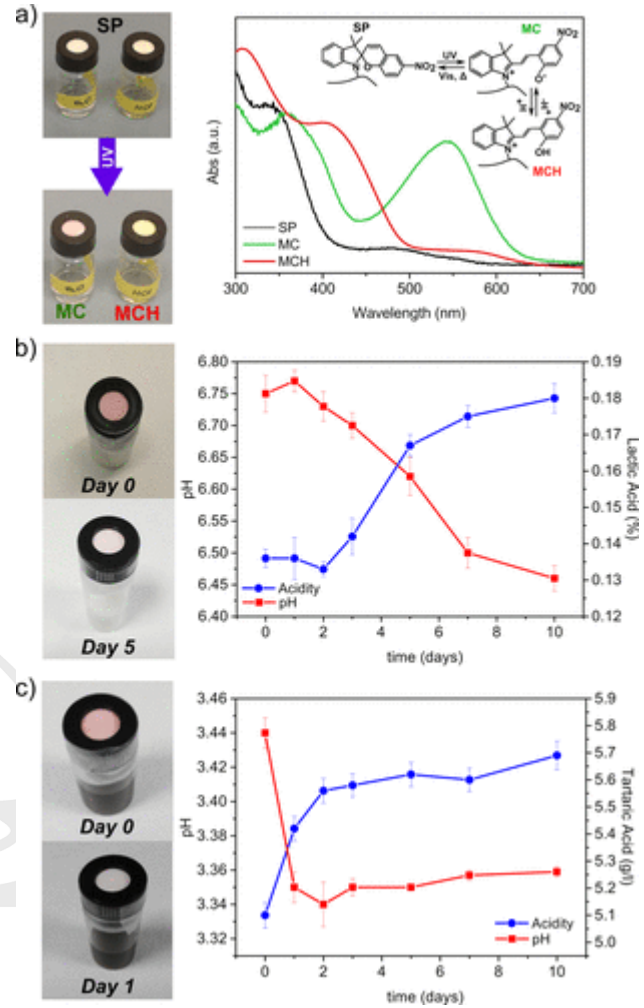
Recycled VS virgin material

Photochromic Paper Indicators for Acidic Food Spoilage Detection

Preparation of FP/SP-PHEMA

The FP (2×2cm² and approx. 400µm thick) was impregnated through immersion in a 3% wt. and in a 25% wt. SP-PHEMA polymer solution in ethanol for 30 s and dried at room temperature.



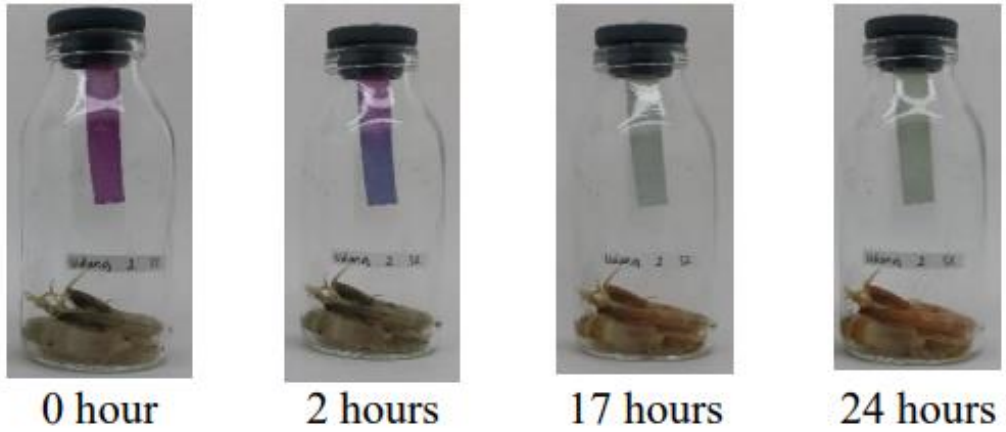


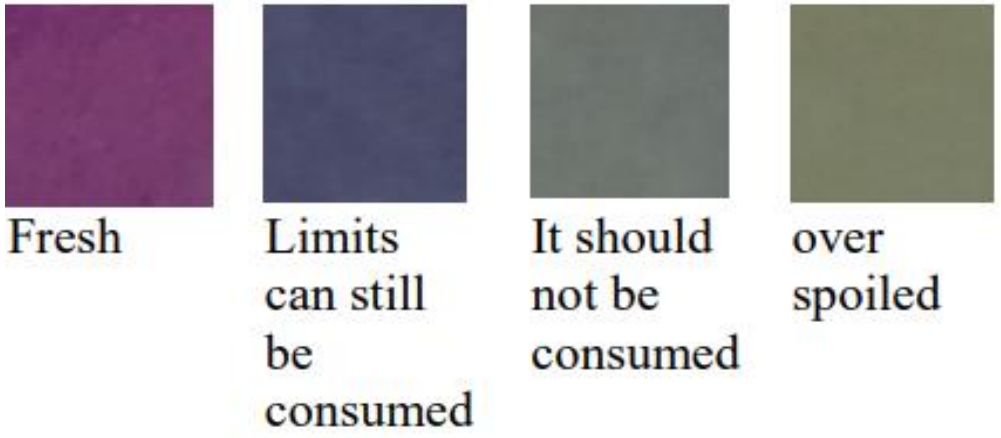
- A photochromic composite based on Filter Paper/SP-PHEMA was fabricated successfully.
- By monitoring samples of milk and red wine for10 days using FP/SP-PHEMA cap (based on pH & total acidity)
- Owing to its outstanding photochromic performance and the acidochromic detection in combination with the low-cost and renewability of the paper substrate, the developed material constitutes ideal smart chips and caps for smart packaging that would allow the in situ assessment of the shelf life of food products against counterfeiting and microbial contaminations.

SP-PHEMA: SP-modified poly(2-hydroxyethylmethacrylate

Maria E. Genovese et al., **Photochromic Paper Indicators for Acidic Food Spoilage Detection.** *ACS Omega* **2018** *3* (10), 13484-13493. DOI: 10.1021/acsomega.8b02570

A paper-based Colorimetric Indicator Label using Natural Dye for Monitoring Shrimp Spoilage



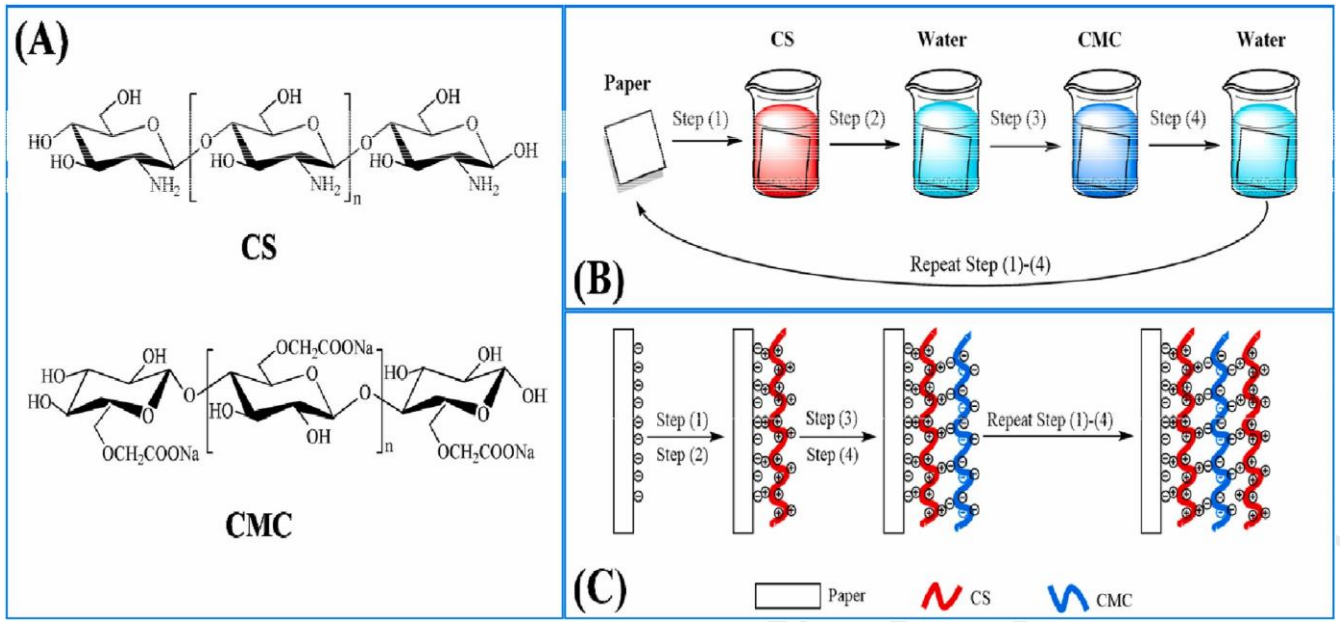


Temperature	Time			
	0 h	2 h	17 h	24 h
13 °C				
25 °C				
40 °C				

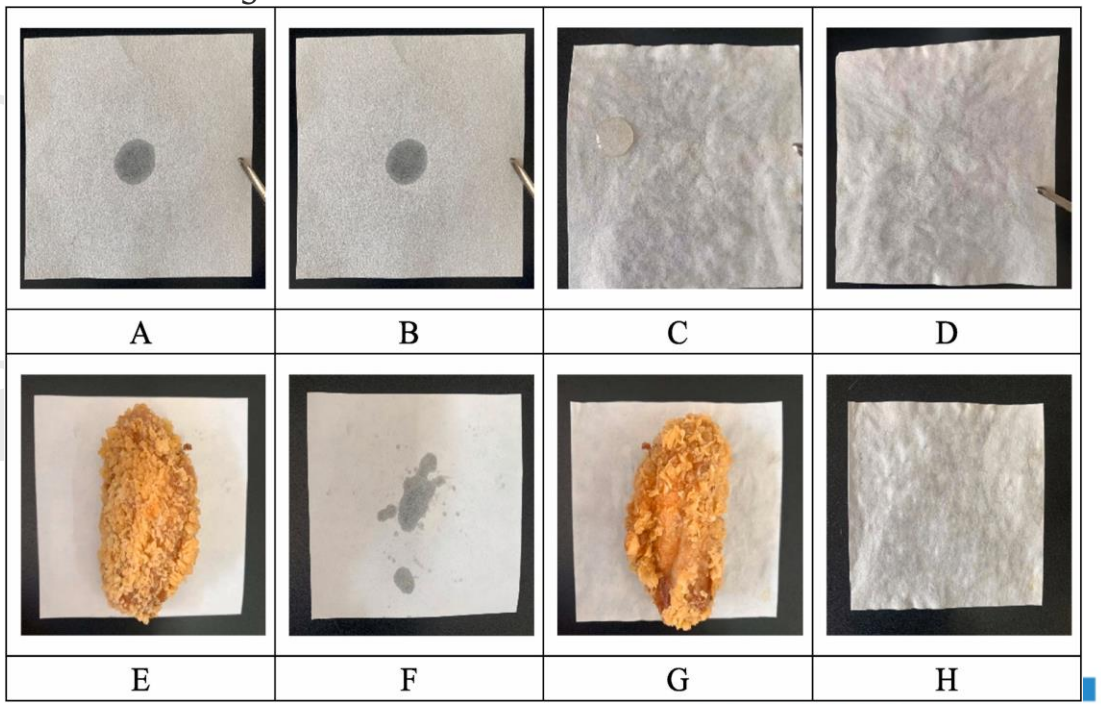
Summary

- A simple method of detecting shrimp freshness has been developed using indicator labels using colored cellulosic paper with Ruellia simplex flower extract.
- The color change of the indicator label from the purplish pink color to the purplish blue, then turns further into greenish-gray and becomes yellowish gray, can be used to express the quality of the shrimp from the fresh to the already rotten sequentially.

Cellulose fiber-based food packaging papers with improved mechanical strength, enhanced barrier against grease & oil



- Images of the front (A) and back (B) of original paper and of the front (C) and back (D) of a $(CS/CMC)_5$ multilayer-modified paper after dripping oil.
- Application images of fried chicken wings placed (E) and removed (F) on original paper and fried chicken wings placed (G) and removed (H) on a $(CS/CMC)_5$ multilayer-modified paper.

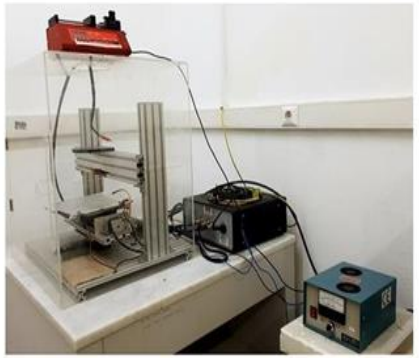


- Successfully prepared a cellulose fiber-based food packaging paper that improved mechanical, barrier, and antibacterial properties using LBL assembly of CS and CMC.
- The paper modified with a $(CS/CMC)_5$ multilayer exhibited an obvious improvement in barrier against grease, oil, and water.
- The cytotoxicity assay results demonstrated the prepared functional food packaging paper was non-toxic

Development of a novel, sustainable, cellulose-based food packaging material and its application for pears

Methodology

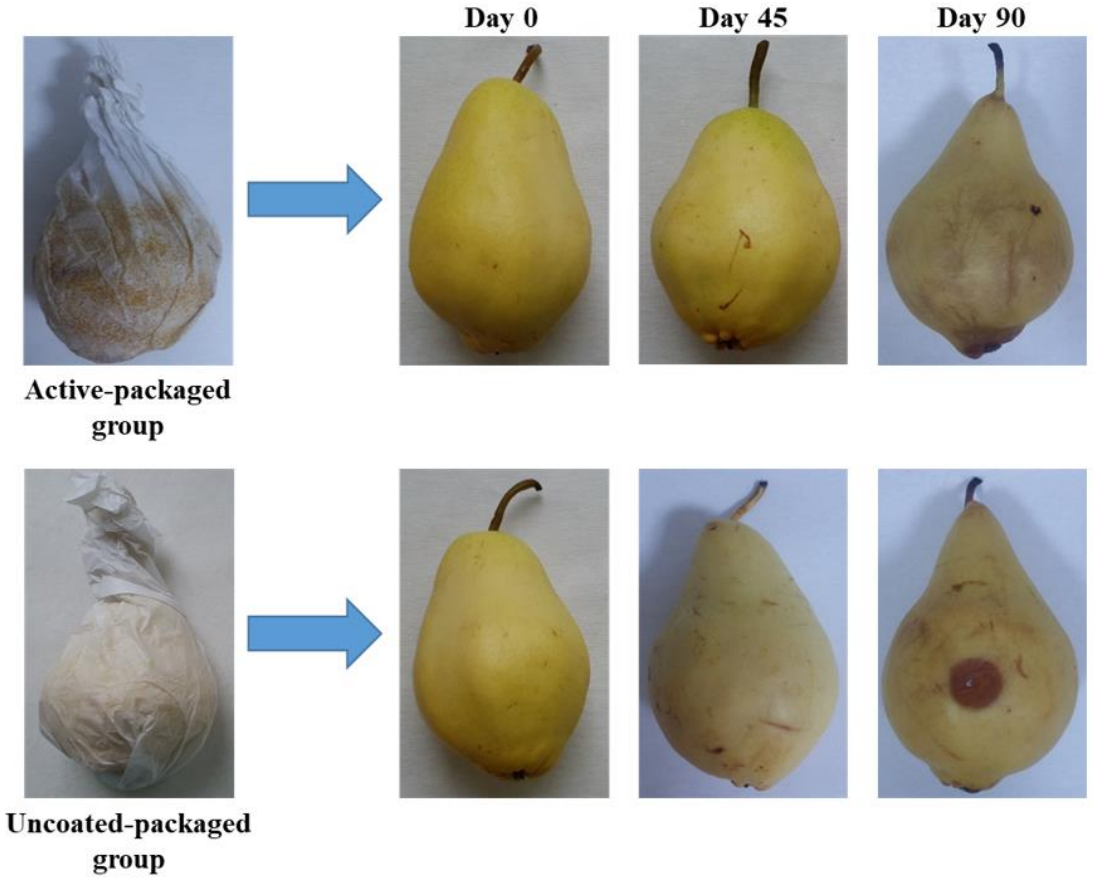
Formulation of antimicrobial coating



Electro spraying on Paper

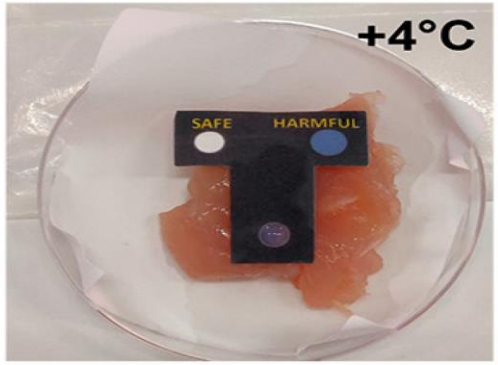
- **Electrospray** technology was practical to coat active molecules on paper.
- **Fulvic acid** and **sericin** mixtures can be effectively used as active molecules
- **Fulvic acid** a type of humic acid is a water-soluble substance produced through the decomposition and transformation of microbial substance that can exhibit antimicrobial and anti-inflammatory properties
- Coated paper exhibits enhanced functionalities e.g. antimicrobial and antioxidant activity
- Sensory analyses revealed that samples stored in the active packaging material were consumable for a longer period than those packed in other packaging materials

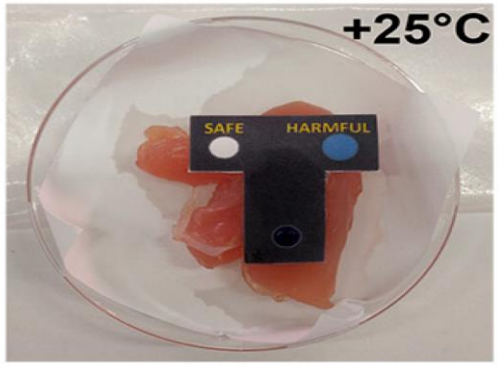
Results



Colorimetric paper sensor for food spoilage based on biogenic amine monitoring.

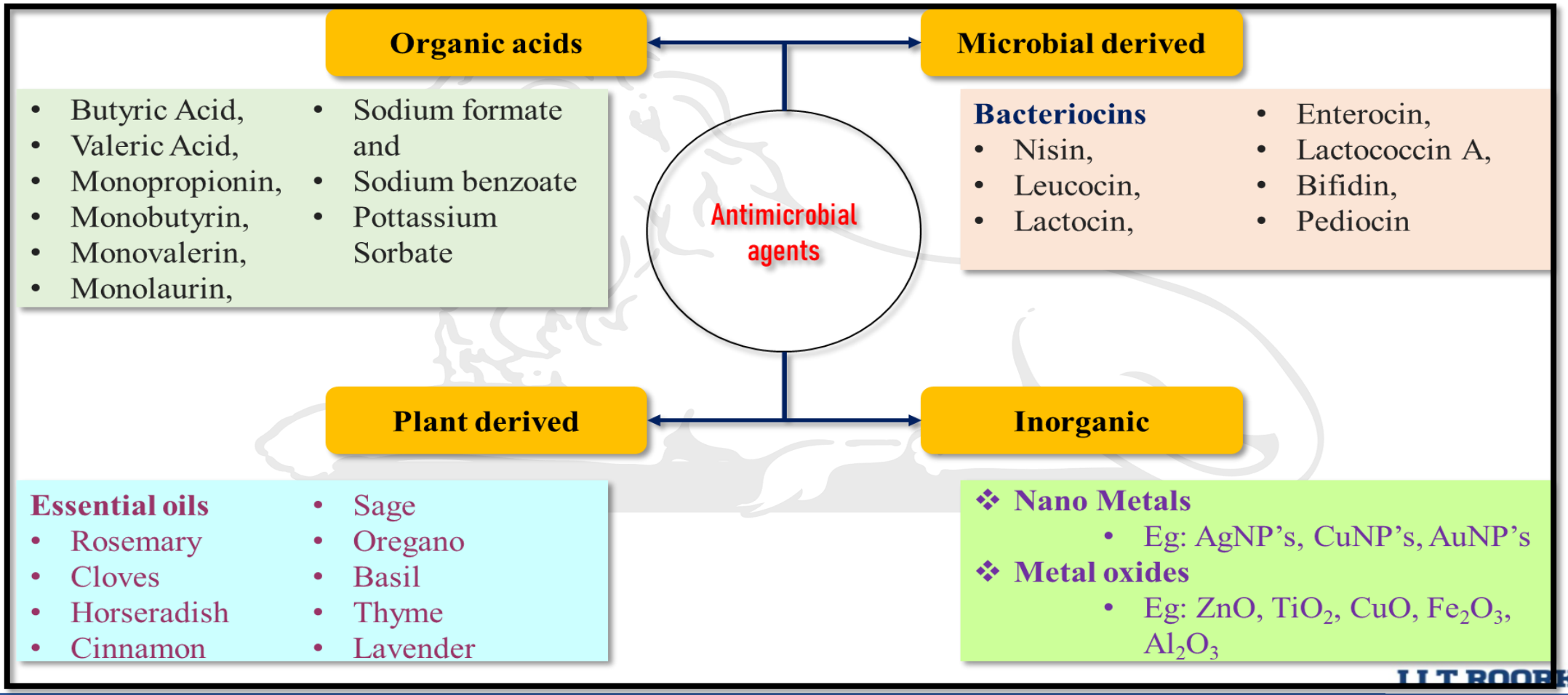
- A user-friendly colorimetric sensing paper able to detect BAs via the naked eye.
- The sensing molecule is the aglycone genipin, a natural cross-linking agent extracted from gardenia fruit, able to bind BAs producing water-soluble blue pigments.
- Genipin was entrapped into a paper sensor to provide a disposable device for BAs, suitable for integration into smart packaging
- The paper-based sensor described here allows quantitative measurements of BAs using small volumes of samples and, thanks to the high intensity of the colorimetric signal, enables quantitative smartphone-based detection.
- The paper sensor was applied to chicken meat quality monitoring



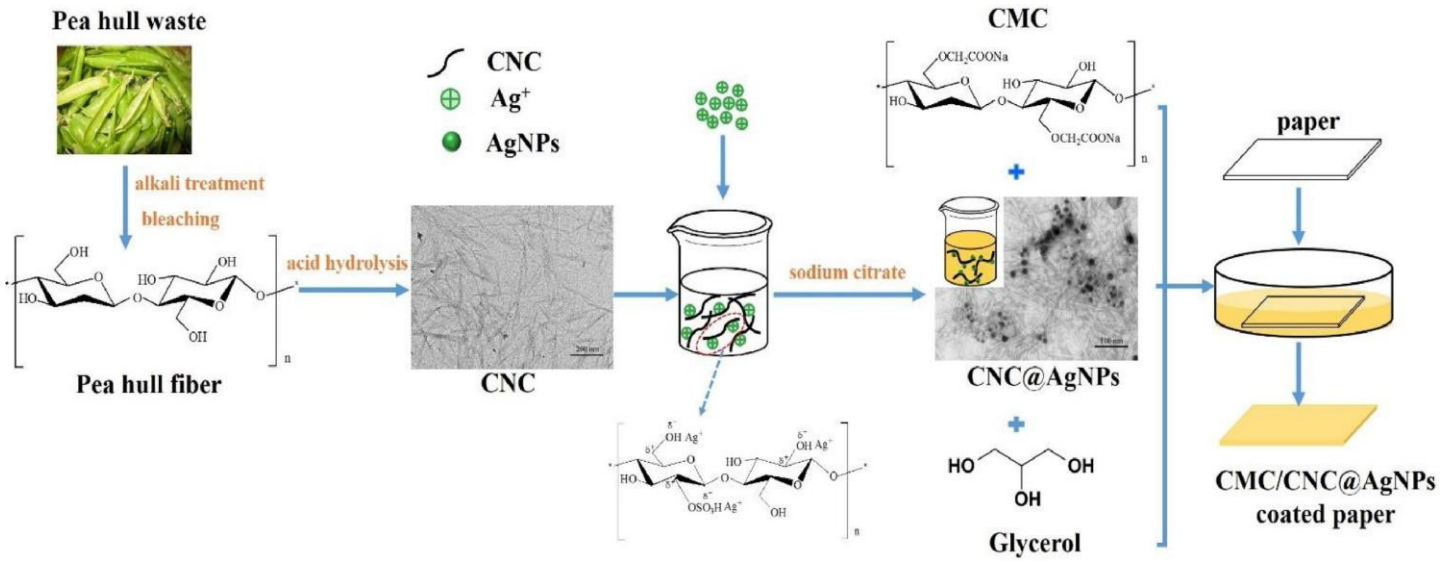


Antimicrobial Paper Packaging

Commonly used antimicrobial agents for direct addition or in the form of coatings

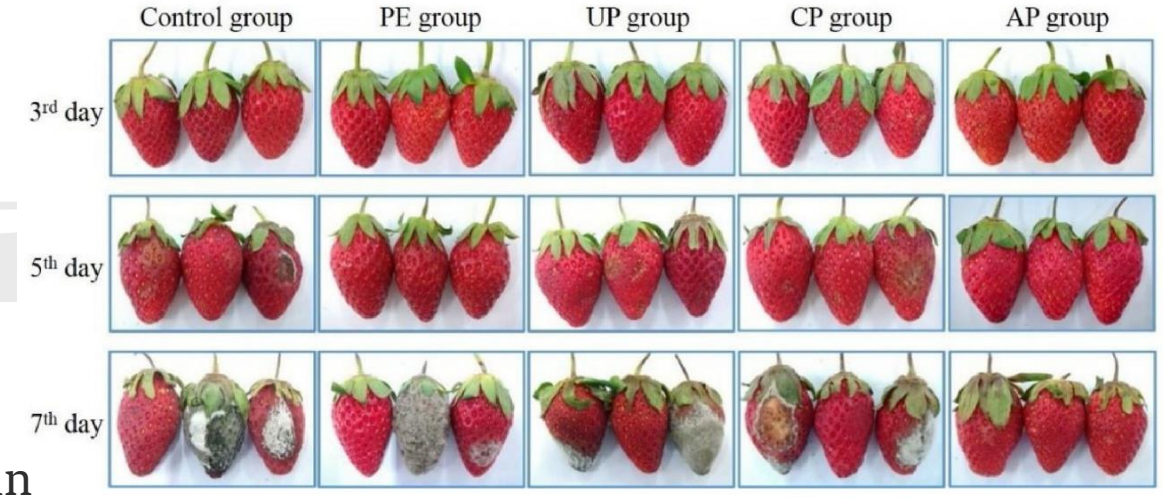


CMC/CNC immobilized AgNPs as an effective coating to improve barrier and antibacterial properties of paper

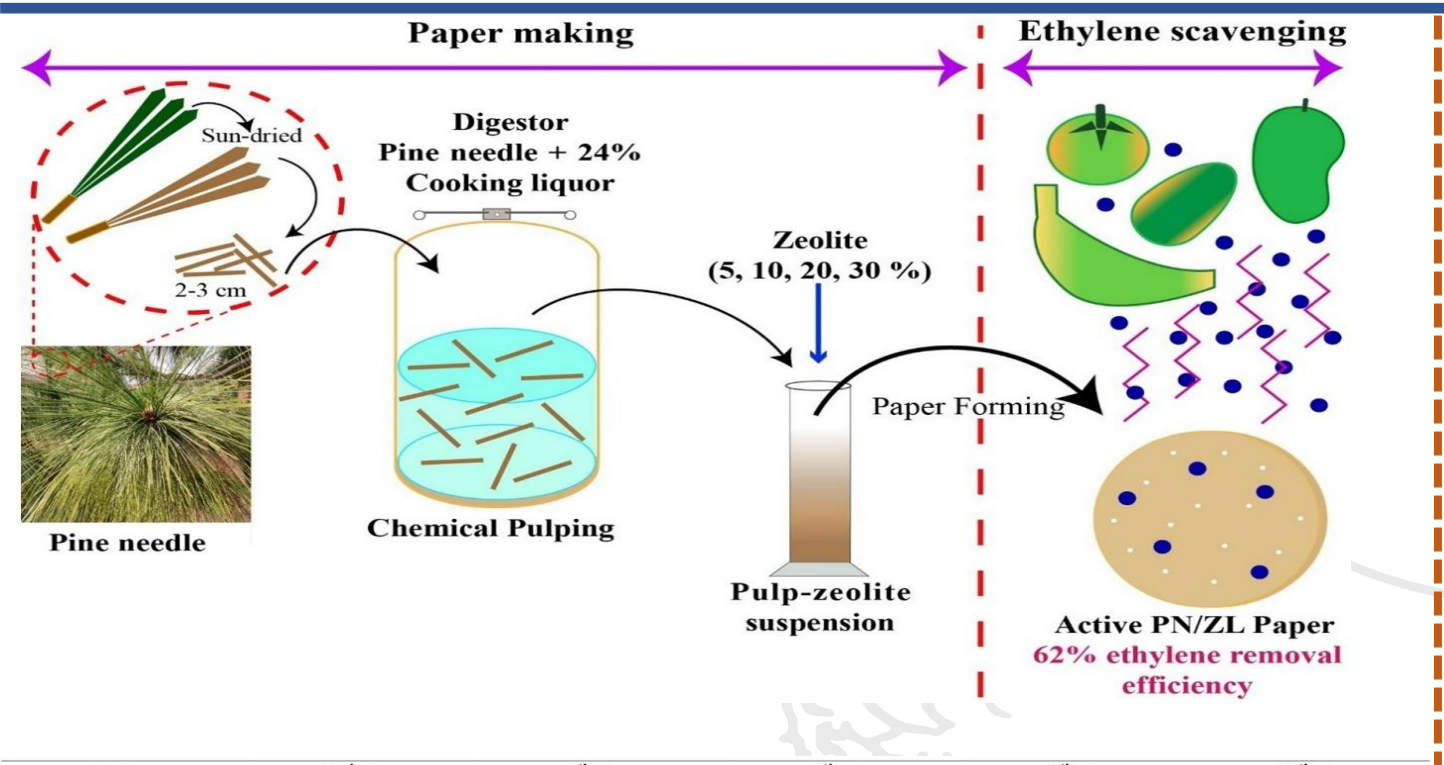


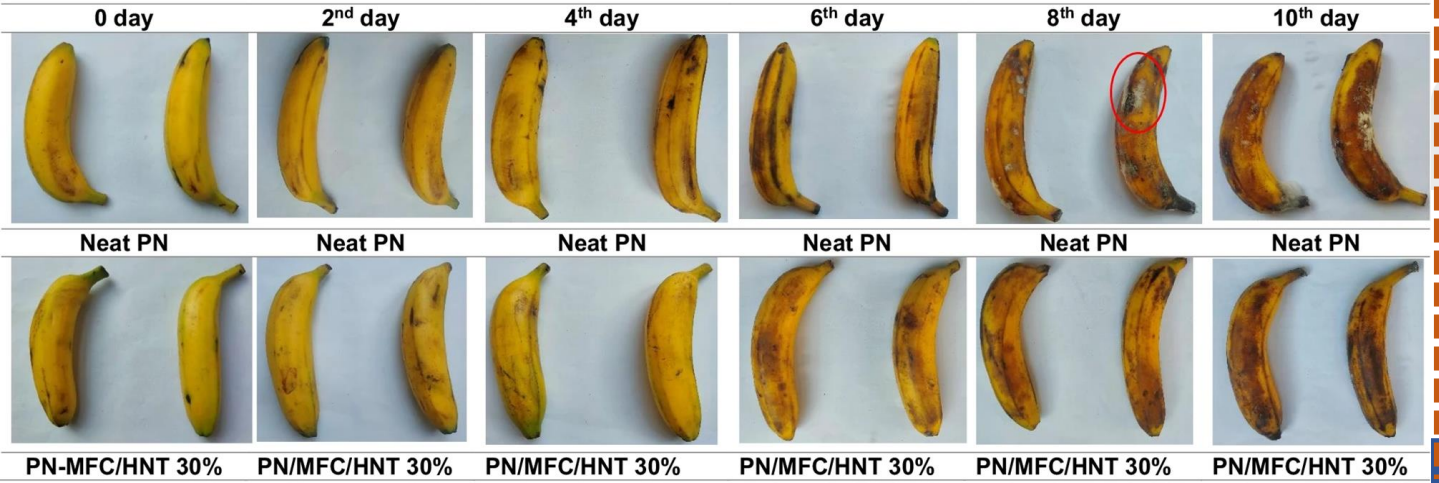
- Strawberry specimens were packaged with the sealed as-prepared coated paper bags (AP group), which was used as the test group.
- No materials (control group), PE bag (PE group), uncoated paper bag (UP group) and CMC-coated paper bag (CP group).
- All the groups were stored under ambient conditions (25 ± 2 °C, 70–75 % RH) for 7 days

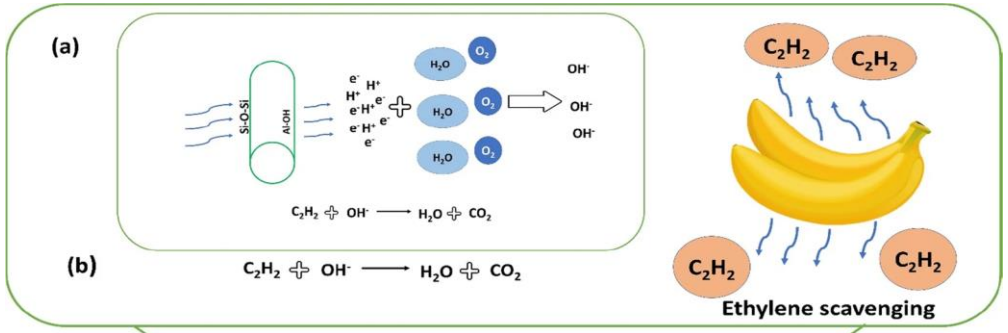
- ✓ Cellulose nanocrystals (CNC) immobilized AgNPs (CNC@AgNPs) were synthesized.
- ✓ CMC/CNC@AgNPs formulations were coated onto paper surface.
- ✓ CMC/CNC@AgNPs coated papers exhibited enhanced mechanical and barrier properties.
- ✓ CMC/CNC@AgNPs coated papers showed excellent antibacterial activities.
- ✓ The obtained functional paper has promising application in food packaging.



Ethylene Scavenging paper made from forest waste







Banana packed in PN/MFC/HNT package

Conclusions

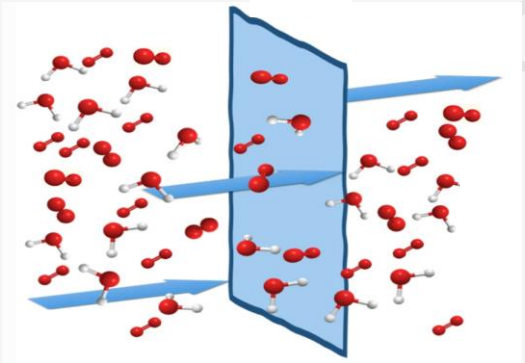
- Pine needle waste was used for paper making
- Zeolite acted as ethylene adsorber
- Shelf life of climacteric fruits can be extended

Barrier coatings on paper

What makes paper unfit for packaging?

Non grease resistant

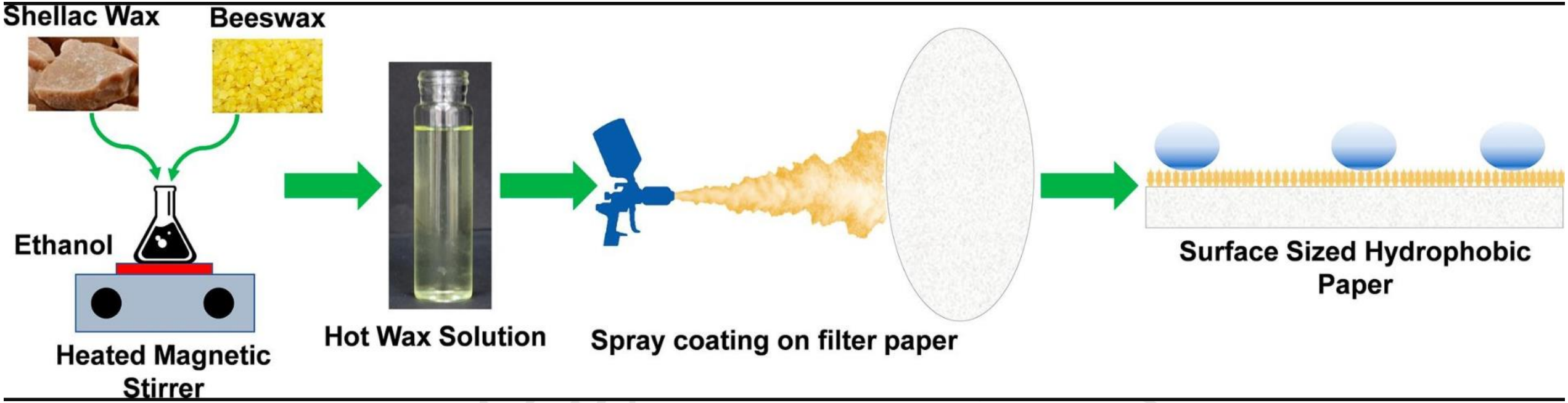
No Moisture resistance



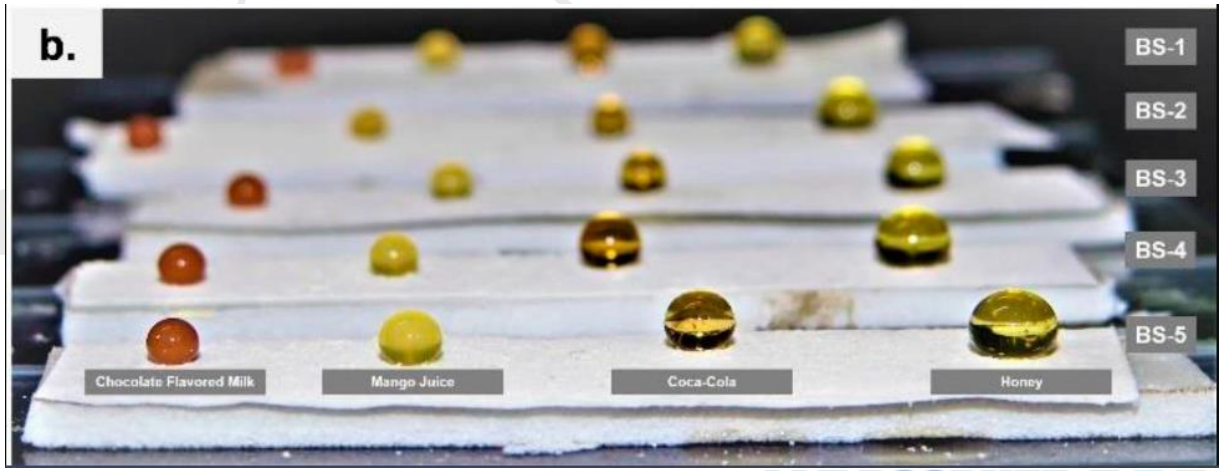
No gas barrier

Solution: Barrier coatings

Barrier coatings on paper



- Beeswax-Shellac wax spray coating on paper produced flower like structure.
- Annealing of coatings enhanced mechanical durability and robustness.
- Contact angle of more than145° was achieved after annealing of coating.
- Coated papers showed good repellency against food products.
- Coated paper showed self-cleaning or anti-fouling properties.



Ahuja, A., & Rastogi, V. K. (2023). Spray coating of edible insect waxes for liquid food packaging. *Applied Surface Science*, *624*, 157150.

Recent Commercial developments in Paper as Food packaging material

Why do we need to focus on food packaging materials?

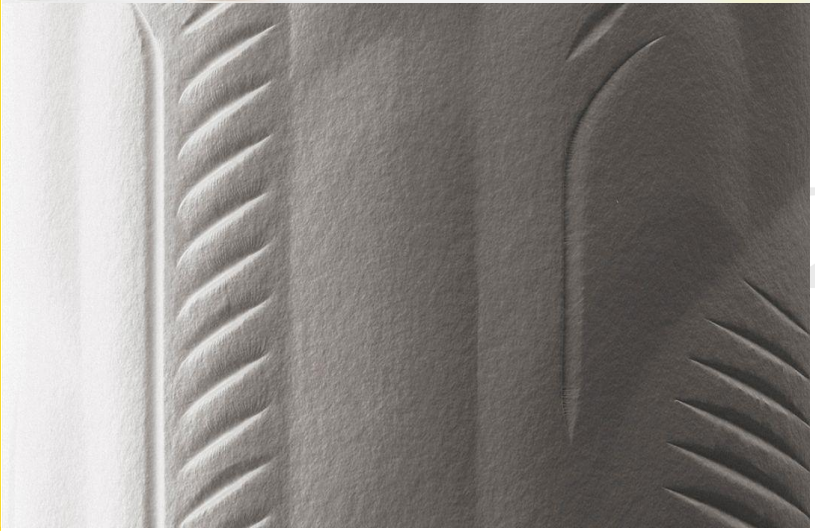
Packaging is part of the first impression your customers have with your food product – make it a good one.

https://envopap.com/

The Good Cup

https://thegoodcup.world/

Molded Paper Bottles for Beverage Packaging



- Recyclable as paper packaging
- 85% paper [14gr]- 15% HDPE barrier [2.6gr]
- Durable and splash resistant paper
- Responsible paper sources – FSC® certified
- Unique haptic and shelf impact from paper bottle surface look and feel - engaging the consumer from first touch
- Available in 500ml and 330ml
- Inquire for customised design project
- Enhance with decoration, embossing and debossing

https://www.paboco.com/bottle

Paper wrappers for chocolate Bars

- ✓ Current plastic wrappers cannot be recycled, as is the case with several other kinds of food packaging.

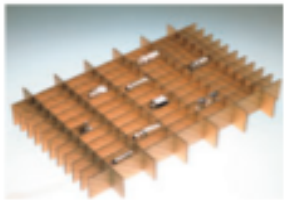
- ✓ Crisps, chocolate, and cheese have traditionally been regarded as the worst foods for packaging recyclability, and big brands have previously come under pressure from customers and campaigners to do more to swap their wrappers to help the environment.

https://www.theguardian.com/business/2023/may/29/mars-bar-wrappers-changed-to-paper-from-plastic-in-uk-trial

Recent Trends in Paper Packaging

Type	Function	Application	Sample
Moisture barrier	Prevent corrugated board from humidity/Moisture	Dry food products	Siliconpack Ltd,  Alfreton, UK
Freshness maintenance	Ability to remove toxic gasses and maintain excellent freshness	Suitable for agro and marine products like fruits, vegetable, flowers and	Kalos Corporation,  Seoul, Korea
Cold storage/ Freshness retention	Corrugated boards coated bottom liner for cool insulation	Ideal for the refrigerated transport of items such as processed marine and meat products	 Rengo Co ltd, Japan

Type	Function	Application	Sample
Water resistance	High level of resistance to water, comparable to wax dipped corrugated packaging, also a high level of recyclability	Use full in dry products packaging	Werner Kenkel  USA
Green pack	Ethylene elimination and gas composition control help to ensure that fruit and vegetable remain fresh	Packaging of fresh produce	MoistTech Corp 
Insect-resistant	A special mixture of ink and varnish coating on corrugated boards repels insects, discouraging them from entering the box	Packaging of food products	Rengo Co ltd,  Japan

Type	Function	Application	Sample
Environmentally friendly	Boxes are environmentally friendly because they do not require staples or tape for sealing.	Any kind of food	
Antirust corrugated	Corrugated packaging with special coating to prevent rust on metallic surfaces. Ideal for inhibiting rust formation on cans contains food	Cans use in food packaging	Shenyang rust proof packaging material co ltd, China 
Anti-slip	Not easily affected by environmental changes, this cardboard provides stable anti-slip functionality	Layer pads and fitments, Palletized loads, Point of sale display packaging	Smurfit Kappa Packaging Product Ltd, UK 

- Sustainable Packaging” Revolution
- Market drivers

- Protect – Inform – Contain – Transport
- Developments of specialty

  Paper packaging through innovation

Functional Food Packaging Lab

“Better Packaging, Better Living”

Thank You for Your Time & Attention!

Prof. Kirtiraj K. Gaikwad, PhD
Indian Institute of Technology
Cell No +91 9897775721