Advances in DNA Technologies for Traceability

Presented by: Dr. Manoj Kumar (Ph.D. Biochemistry)
Scientist: ICAR – Central Institute for Research on Cotton Technology, Mumbai, India
Email: manoj.kumar13@icar.gov.in

81ST PLENARY MEETING
MUMBAI, INDIA
2-5 December 2023

Cotton Value Chain:
“Local Innovations for Global Prosperity”
Outline

- Introduction: Fiber traceability, Need and Importance
- Background: Traditional V/S DNA based fiber traceability
- DNA Technologies Application in Textile Overview
- How DNA traceability works
- DNA Based Traceability Technique
- Case studies
- Conclusion
Introduction: Fiber traceability, Need and Importance

Fiber Traceability: Tracing the journey of fibers from their source, through various manufacturing and processing stages, to the final product.

Textile Industry's Need for Traceability:

1. Growing, Ginning, Trading
   - Cotton is grown in different regions and ginned to remove seeds.

2. Spinning, Knitting or Weaving, Dyeing
   - Cotton is spun into yarn, knitted into fabric, or woven into fabric, and then dyed.

3. Garment QC System
   - Quality control systems are used to ensure the garments are made according to specifications.

4. Brand Orders Its Apparel
   - Brands place orders for garments that are then manufactured.

5. Cutting, Sewing, Trimming
   - Garments are cut and sewn together, and any necessary trimming is done.

6. Embroidery, Printing, Washing
   - Garments are often embroidered, printed, or washed to meet specific requirements.

7. Warehousing, Shipping
   - Garments are stored in warehouses before being shipped to retailers.

8. Retail
   - Garments are sold in stores to consumers.

Importance of Traceability

- Sustainability
- Consumer Confidence

ICAC - 81st Plenary Meeting: Cotton Value Chain: Local Innovations for Global Prosperity
02-05 Dec 2023, Jio Convention Centre, Mumbai, India
**Background: Traditional V/S DNA based fiber traceability**

**DID YOU KNOW?**
43% of people say origin matters when deciding what brands they like and support in 2022

*Source: Environmental Leader, 2022*

<table>
<thead>
<tr>
<th>Traditional fiber traceability</th>
<th>DNA based fiber traceability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susceptible to tampering and counterfeiting</td>
<td>Highly Secure and difficult to counterfeit</td>
</tr>
<tr>
<td>Manual data entry prone to errors</td>
<td>Enables traceability from raw materials to finished products</td>
</tr>
<tr>
<td>Limited traceability throughout the entire supply chain</td>
<td>Underpinned by Science: Greater accuracy and reliability of data</td>
</tr>
</tbody>
</table>

*Source: The Textile Think Tank, 2022*
DNA Technologies Application in Textile Overview

- **Fiber Authentication**
  - 1. Anti-Counterfeiting
  - 2. Supply Chain Transparency

- **Traceability in Supply Chain**
  - 1. Quality control
  - 2. Compliance

- **Cotton DNA Fingerprinting**
  - 1. Create unique fingerprints
  - 2. Origin Verification

- **Textile Recycling**
  - 1. Material sorting
  - 2. Circular economy initiatives

- **Anti-Counterfeiting in Apparel**
  - 1. Market protection
  - 2. Regulation

- **Quality Control and Testing**
  - 1. Material purity testing
  - 2. Product safety assurance

**ICAC - 81st Plenary Meeting: Cotton Value Chain: Local Innovations for Global Prosperity**
**02-05 Dec 2023, Jio Convention Centre, Mumbai, India**
Ideal DNA marker/solution

Versatile
Distinct markers for each manufacturer, production step

Easily integrated
Easy to apply; does not affect production steps.

Robust
Resilient to mechanical and chemical processing

Harmless
Non-toxic, GMO-free

Specificity
Accurately identifies the target DNA sequence with high specificity

Technological Compatibility
Compatibility with PCR or NGS.

Cost effective
Consider cost-effectiveness when selecting a marker

(Source: Amiteye, 2021)
How DNA traceability works

1. Product absorbs synthesized DNA marker, giving product its unique origin fingerprint.
2. Products from market are tested to verify the origin of the product.
3. Samples from the market can be collected for testing.
5. Certification & authentication.

Source: [https://oritain.com/our-science/oritain-science-explained/](https://oritain.com/our-science/oritain-science-explained/)
**DNA Based Traceability Technique**

“DNA molecular tagging” integrates DNA into fibers and employs extraction, sequencing for verification, ensuring durability and integrity of the textile product.

*Gossypium hirsutum*: American cotton  
*Gossypium barbadense*: Egyptian cotton  
*Gossypium arboreum*: Asiatic/Indian Cotton  
*Gossypium herbaceum*: Sub-Saharan African and Arabian  
(Source: Das et al., 2017)

(Kuzdraliński et al., 2023)
Case study

Is your sweater REALLY 100% cashmere? Chinese factories are accused of blending goat's wool with rat's fur and other cheaper fabrics

[Article Link]

Identification of Cashmere and Wool by DNA Barcode
Identification of Cashmere and Wool by DNA Barcode

Extraction of DNA from both types of animal fibers

PCR to amplify the small amount of DNA.

Identification of the species of cashmere and wool using DNA

Sequencing the target DNA

Comparing the sequences to a database to accurately identify the animal origin of the samples

Kashmir Goat

Cashmere

$110-$170/kg

Sheep

Wool

$22-$55/kg

https://www.raisingsheep.net/how-much-is-sheep-wool-worth
DNA Based Traceability of Organic Cotton: A case study

The New York Times
*That Organic Cotton T-Shirt May Not Be as Organic as You Think*

**Problem:**
Reliance on paper-based transaction

**Solution:**
DNA tagging and traceability

**Example: Fashion for Good Organic Cotton Traceability Pilot Study**

- Cotton cultivated in Segaon, Madhya Pradesh
- Marker applied on cotton in farms using hand or automated sprayer
- Haelixa DNA tracer is detected using a portable, forensic grade DNA verification device
- Field study traces 75 MT of organic cotton from farm to retail

ICAC - 81st Plenary Meeting: Cotton Value Chain: Local Innovations for Global Prosperity
02-05 Dec 2023, Jio Convention Centre, Mumbai, India
Marking Technology is gaining space in the textile industry

Tagging Process

Cotton grown, harvested and transported to gin
SigNature T DNA, applied by misting process attaches to the fiber at a cotton-to-marker ratio of 1:1 billion
Compacted into 500-pound bales, barcoded and tracked

Tracking Activities

Bales tested for SigNature T DNA marker

Companies using this technology:

Finished product tested for SigNature T DNA marker
Freshly woven fabric tested for SigNature T DNA marker
Spun fiber tested for SigNature T DNA marker

ICAC - 81st Plenary Meeting: Cotton Value Chain: Local Innovations for Global Prosperity
02-05 Dec 2023, Jio Convention Centre, Mumbai, India
Marking Technology is gaining space in the textile industry

Traceable Premium Egyptian Cotton
By Swiss company “Haelixa” from the source up to premium shirts

Unique DNA marker developed for Egyptian cotton (GIZA 96) by Haelixa

DNA marker applied as fine spray to cotton lint in Borg Al Arab, Egypt

Cotton lint tested for DNA marker by PCR

Shipped en route to Weba for production of finest fabric

Marked fabric was used to make Hugo Boss cotton dress shirts

Forensic data is recorded on a blockchain system provided by United Nations Economic Commission for Europe (UNECE)

Fabric at Weba tested for DNA marker by PCR

Cotton yarn tested for DNA marker by PCR
Benefits of Traceability in Textile Industry

- Continuous Improvement
- Easier Product Return
- Better Customer Retention
- Improved Company Reputation
- Streamlined Inventory Management
- Better Compliance
- Higher Quality Products

Benefits of Traceability
Issues With Fiber Traceability

Drawbacks of DNA-based Traceability

- High implementation costs
- Complexity of DNA analysis and verification
- Potential privacy concerns
**Conclusion**

- **Enhanced Accuracy and Reliability:** Offers a significant improvement in accuracy and reliability compared to traditional methods.

- **Consumer Confidence and Transparency:** It enhances consumer confidence by providing transparent information about the origin and authenticity of textile products.

- **Address sustainability:** DNA traceability can be employed to verify the authenticity of sustainable and eco-friendly fibers, such as organic cotton.
Acknowledgement

✓ ICAC, Washington D.C., USA.
✓ Director, ICAR – CIRCOT, Mumbai
✓ ICAR
**Marking and Verification**

**Verification**: via qPCR test. Results integrate with blockchain technology, or digital interfaces, ensuring traceability. Origin details can be shared with consumers via a QR code.

**Marking**: Engineered unique **marker** is dispersed in water, sprayed during production adhering to the fiber until the final garment is produced.
DNA-based tagging

- Unambiguous Identification
- Genetic information
- Identification of mutations
- Facilitating Transparent Data Analysis

(Kuzdraliński et al., 2023)