Sustainable building materials from rice straw

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Overview presentation

- Introduction
- Sustainable building
- Building materials from rice byproducts
- Product development
Transition towards “Biobased economy”
Transition to a bio-based economy

biomass resources
abundantly available
at competing cost
for sustainable development
Options for sustainable building

- Reuse and recycling of building materials

- Energy saving
  - by insulation
  - during production of building materials
  - alternative energy sources (photovoltaic cells, heat pumps)

- Application of renewable resources
Ecological building
Sustainable building: Adobe
Sustainable building: Ecolonia
Sustainable building: Wood frame
Sustainable building: Straw bale
Sustainable building: Agrodôme
Building material selection: Agrodôme

- Foundation
- Ground floor
- Outer walls
  - massive wall
  - cavity wall
- Floors / ceiling
- Roofing material
  - pitched or flat
- Coatings/Adhesives
- Paint
- Insulation

- inside walls
  - supporting wall
  - partition wall
Rice

Byproducts

- Rice Husk
- Rice Straw
Building Materials

- **Rice straw**
  - Particle board
  - Medium density fibre board
  - Straw Board
  - Straw Bales
  - Thatched roofs
  - Cement bonded boards
  - Composites

- **Rice husk**
  - Cement
  - Gypsum Board
Rice straw: Particle board

- **Use**
  - Inner walls
  - Sound absorbing

- **Production Process**
  - UF: urea formaldehyde resin

- **Improvements**
  - Mechanical strength
  - Water Absorption

[Hiziroglu, 2005] [Yang, 2003]
Rice Straw: Medium Density Fibreboard

- **Use:**
  - Walls, ceilings, furniture

- **Resin**
  - UF: Urea Formaldehyde
  - MUF: Melamine urea Formaldehyde
  - pMDI: polymeric methylene diphenyl diisocyanate

- **Improvement**
  - Silica: Cutting tool wear
  - Mechanical strength
  - Water resistance

[Hiziroglu 2007]
California Agriboard LLC [McLeod, 2004]
Rice Straw: Straw board

- **Use**
  - Walls, Roofing

- **Production process**
  - Without binder
  - With binder
  - Covered with outside layers

- **Improvements**
  - Mechanical properties
Rice straw: Cement bonded boards

- **Use**
  - Building blocks
  - Ceiling panels

- **Straw-fibre cement building blocks**
  - Cheap recyclable building material
  - Low strength
  - Thermal insulation

- **Improvements**
  - Bond between straw and cement
  - Acidity straw

[Mansour, 2007]
Rice straw: Thatched Roofs

- Improvements
  - Fire Hazard
  - Durability

[Matt Carter, 1997]
Rice straw: Composite board

Waste Tires - Rice straw

- **Use**
  - Sound absorbing insulation boards in construction

- **Production Process**
  - Cutting/Milling
  - Polyurethane binder
  - Hot pressing

- **Improvements**
  - Toxicity check
  -Compatibilisers
  - Process

[Yang, 2004]
Rice straw: Composites

- **Thermoplastics**
  - Polyethylene [Yao, 2008] [Habibi, 2008]
  - Polypropylene [Grazdanov, 2006]
- **Thermoset**
  - Polyester [Hassan, 2002]
  - Polyvinylchloride (PVC) [Kamel, 2004]
- **Improvements**
  - Mechanical properties
  - Compatibilisers
  - Chemical pretreatment straw
Rice straw: BioComposites

- Composites of biobased plastics and fibres
  - PHBV: Poly HydroxyButyrate-co-hydroxyValerate
  - PLA: Poly Lactic Acid

- Use
  - Structural, thermal insulating panels

- Improvements
  - Mechanical strength
  - Economics

[Buzarovska, 2008]
Rice Husk: Gypsum board

- Use
  - Wall panels
  - Ceiling panels

- Production process
  - Husk content <30%
  - Cold production using citric acid

- Properties
  - Increased mechanical properties
  - Decreased water absorption

[Kim, 2009]
Rice husk: Cement

Large experience in rice husk cement and concrete

- Use
  - Rice hull ash is converted to $\beta$-Ca$_2$SiO$_4$ a component of commercial portland cement
  - Lightweight insulating concretes for low cost housing

[Salas, 1986] [Romano, 2007] [de Paiva, 2005] [El-Dakrouy, 2008]
Rice husk: CLSM

Self-Compacting low-strength, cementitious materials

- **Use**
  - Backfill, void fill, utility bedding

- **Composition**
  - Fine aggregates, Portland Cement, water, rice husk ash

- **Rice husk ash:**
  - pozzalanic properties

[Nataraja, 2007]
Rice Straw: High end applications

- Hierarchical porous carbon from rice straw
  - Lithium ion batteries
  - High rate performance
  - High capacity
  [Zhang, 2008]

- Textile fibres
  - Chemical and enzymatic extraction
  - Natural cellulose fibres
  - Properties comparable to linen
  [Reddy, 2006]
Product development

- Product at competing price
- Product with new properties
- New technologies
- New products
Biomass from agro-industrial residues

World production capacity coconut husk
15-20 million tons /year
Building and construction materials
Composites
Conclusions

- Multiple opportunities for Rice Byproducts in sustainable building materials
  - Alternatives for existing wood products
  - New products

- Product development necessary
  - Improve products
  - Economy processes

- Rice straw part of Biobased Economy
Thank you for your attention.