International Symposium on Assessing the Economic Impact of Nanotechnology
Session Two: Exploring the qualitative dimensions of the economic impact of nanotechnology
Assessing the breadth of the potential Economic Impact of Nanotechnology

Applications: Food & Food Packaging

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Embrapa – Current Perspective

Established in 1973
(model of private company, but public owned)
Employees: 8,916
Total Scientists: 2,000+
Budget-2011: US$ 1.2 billion

46 Research Centers

16 National Commodity Centers
16 Ecorregional/Agroforestry Centers
13 National Thematic Centers
Embrapa Research Centers

Embrapa

Headquarter

◆ 13 Thematic Centers

▲ 16 Commodities/product

■ 16 Ecorregional and forestry

● 03 Special Services
Brazilian Tropical Agriculture: before 1970's

- Low Ag Production (few items)
- Low Productivity
- Yield Shortages, Food Supply Crisis
- Expensive Food, Inflation, Poverty
- Inadequate Ag Public Policies
- Lack of Specific Knowledge about Tropical Ag
- Institutional void (ag research, education, markets, midia and governmental agencies, etc)

THE TASK: TO MOVE FROM AGRICULTURE APPLIED TO THE TROPICS TO TROPICAL AGRICULTURE
Outcomes

- Public policies
- Institutional building
- R&D to foster knowledge in tropical agriculture
Agricultural Production

Leading exporter in Agricultural Products
Brazil 2th place (after USA)
International Cooperation

Bilateral Cooperation
- Institutes, Universities
- Labex USA (North America)
- Labex Europe
- Labex Korea (Asia)
- Embrapa Americas (Panama-new)
- Venezuela- Office TT
- Embrapa Africa (Ghana)

Multilateral Agreements
- CGIAR
- PROCIS–Procisur, Procitrópicos

Reverse LABEX
- In 1984 was established the National Instrumentation Centre for Agriculture, Embrapa Instrumentation, São Carlos, São Paulo State.

- National Nanotechnology Laboratory for Agriculture (LNNA) - 2008
Macroprogram 1
Brazilian National Challenges
Network Project

Nanotechnology applied to Agribusiness

1st Period: 2006 - 2010
2nd Period: 2011 - 2014

Embrapa Instrumentation
1st Period (2006-2010) focused in building the capacity (the research network) in 3 main areas:

- Sensors and biosensors for applications in food and agriculture
- Films and coatings for food package and direct coating in foods (edible films)
- New applications in agriculture-based materials (fibers, residues, etc)
• 2nd Period (2011-2014) focused in expanding the research network and incorporating of new research in 6 main areas:

- Sensors and biosensors
- Thin films for packing and edible coatings
- Bionanocomposites
- New applications for conventional nanomaterials (inorganic nanoparticles and coatings, etc) in agribusiness
- Safety and toxicological aspects of Nanotechnology
- Technology transference for the private sector and society in Nanotechnology
Cellulose Nanofibers: from different sources

1-white and colored cotton
2-curauá
3-sisal
4- sugarcane bagasse
5- coconut fiber waste
Cellulose nanowhiskers from coconut fiber (CNPAT)

- SEM / TEM

- Bleached coconut fiber

- Nanowhiskers from coconut:
  - Different shape
  - Length: 100 – 500 nm
  - Diameter: 4 – 6 nm
  - Aspect ratio ~ 28

- Nanowhiskers from cotton:
  - Aspect ratio ~ 10
“Electronic tongue”

Electronic tongue

Analytical Chemistry, 2003

liquid medium
analytes
nanostructured film

signal transduction

Capacitance (fF)

Different sensing units

1 2 3 4 5 ... N

sulphite
sweetness

“Fingerprint” of the taste

data processing
Artificial Neural Networks

simple, rapid reversible monitoring sample recognition Quality Control
Tasting coffees (electronic tongue)
Wines from different vineyards (electronic tongue)

CSA Cabernet Sauvignon A
CA Cabernet A
MA Merlot A
GRA Gamay Rosé A
RA Riesling A
GWA Gewürztraminer A
UB Ugni Blanc A
CSE Cabernet Sauvignon Embrapa
CFE Cabernet Franc Embrapa
RE Blend Embrapa
T1 Table wine 1
T2 Table wine 2
Detection of Microcystin

Capacitance variation on each sensor under different concentrations of Microcystin: 150µg/L (red); 100µg/L (green); 80µg/L (blue); 20µg/L (black); water (red+star)
Conductive gels

Flexible self-standing films

Cellulose & Polyaniline Nanocomposite

Electrically conductive nanocomposites made from cellulose nanofibrils and polyaniline. U.S. Patent App. 2010 (Medeiros, Mattoso, Orts)

40 30 20 10  5 2.5 0 % Pani/CnF

Conductive gels

Flexible self-standing films
Nanoparticles of natural polymers (chitosan, pectin, starch)

Application: packaging, antimicrobial, strength reinforcement, controlled release
Edible Films: biopolymers directly applied in food to modify surface properties

Carboxymethylcellulose

Chitosan

Zein

Credits: Embrapa Instrumentation (Dr. Odílio B. G. Assis)
**Hidrogel: controlled release**

**Swelling curves of PAAm-MC hydrogels in a pH ~ 7.0 at 25 °C.**

Cooperation, Embrapa/USDA/UEM

\[
DS = \frac{\text{swollen mass}}{\text{dry mass}}, \text{values between 10 – 100} \times \\
* 1 \text{ g of dry hydrogels } \Rightarrow 100 \text{ g of water-uptake}
\]

Methyl Cellulose improves water-uptake
Currently under developing:

- Electronic nose (quantify ethylene gas concentration in mature fruits)
- Genetic bar code for algae species
Impact and nanotechnologies in Embrapa:

Embrapa is forming a big team in Brazil and is leading this theme related to agriculture.

Basically are considered two situations:

- Economic impact (easier to be calculated)
  Chain value and all the related tools

- Social/enviromental impact (for the moment is subjective)
  interviews with the chain value actors such as rural or industrial producers; new technology adopters, or users; society in general.
  All the questionnaire responses are scored and weighted by the interviewer (the subjective action).
- Nanotechnology applied in agribusiness is one of the areas that Brazil can be highly competitive.

- It can bring revolutionary solutions or improvement from the upstream to the downstream of the value chain.

- Nanosensors applied in the whole value chain, nanocatalyzers (intended to diagnose plant diseases), molecular treatment in plants, improvement of nutrient and fertilizer absorption, nanocomposites applied to packages and new materials, nanodevices for traceability, etc.
Thank you for your attention!