A 2020 VISION OF FOOD ENGINEERING 28-06-10

Gustavo V. Barbosa Cánovas

Center for Nonthermal Processing of Food

WASHINGTON STATE UNIVERSITY

INTRODUCTION

- **Food is a unique source of energy for the human body. Therefore, the food supply has been a specific concern of people and authorities in every country around the globe**

- **Demand for easy-to-cook food with sufficient nutrients for the body has significantly increased during the last decade**

- **Food engineering research topics are constantly changing, but the goal is to find and design better techniques (or strategies) to improving the shelf life and nutrition content of processed food**

CHANGING WORLD

- ***Just as society has evolved over time, our food system has also evolved over centuries into a global system of immense size and complexity. The commitment of food science and engineering professionals to advancing the science of food, ensuring a safe and abundant food supply, and contributing to healthier people everywhere is integral to that evolution.***

- ***As the food system has drastically changed, from one centered around family food production on individual farms and home food preservation to the modern system of today, most people are not connected to their food nor are they familiar with agricultural production and food manufacturing designed for better food safety and quality.***

DELPHI ORACLE

GUSTAVO ASKING FOR THE FUTURE OF FOOD ENGINEERING

US NATIONAL ACADEMY OF ENGINEERING

The engineer design devices, components, subsystems, and systems and, to create a successful design, in the sense that it leads directly or indirectly to an improvement in our quality of life, must work within the constraints provided by technical, economic, business, political, social and ethical issues. Technology is the outcome of engineering; it is rare that science translates directly to technology, just as it is not true that engineering is just applied science

TECHNOLOGICAL CHALLENGES

- The engineer of 2020 will need to be conversant with and embrace a whole realm of new technologies, but some old problems are not going to go away. They will demand new attention and, perhaps, new technologies. In some cases their continuing neglect will move them from problems to crises.

US NAE: ABOUT 2020 PREDICTIONS

- Because precise predictions are difficult at best, NAE approached this issue by using the technique of scenario-based planning.

- Specific scenarios considered were:
  - The Next Science Revolution
  - The Biotechnology Revolution in a Societal Context
  - The Natural World Interrupts the Technology Cycle
  - Global Conflict or Globalization

THE NEXT SCIENTIFIC REVOLUTION

- This scenario offers an optimistic future where change is principally driven by developments in technology. The future will follow a predictable path where technologies that are in the horizons today are developed to a state where they can be used in commercial applications and their role is optimized to the benefit of the society

THE BIOTECHNOLOGY REVOLUTION

- This one speaks to a specific are of science and engineering that holds great potential but considers a perspective where political and societal implications could intervene in its use. In this version of the future, issues that impact technological change beyond the scope of engineering become significant, as seen in the current debate over the use of transgenic foods.

THE NATURAL WORLD

- This scenario recognizes that events originating beyond man's control, such as natural disasters, can still be a determinate in the future. While in this case the role of future engineers and new technologies will be important so speeding a recovery from a disastrous event. It also can help in improving our ability to predict risk and adapt systems to prepare for the possibilities to minimize impact.

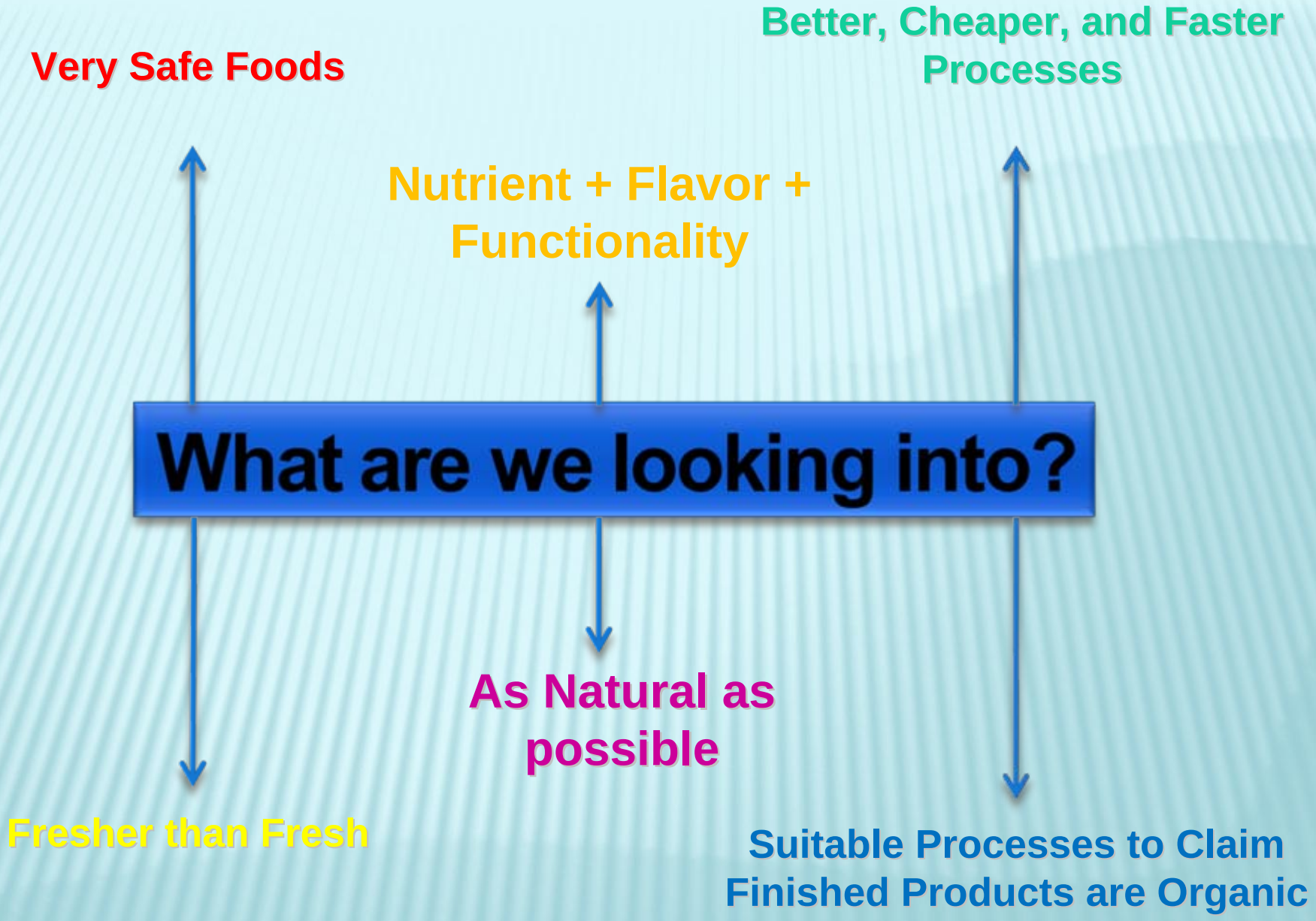
GLOBAL CONFLICT OR GLOBALIZATION

- This scenario examines the influence of global changes, as these can impact the future through conflict or, more broadly, through globalization. Engineering is particularly sensitive to such issues because it speaks through an international language of mathematics, science, and technology. Today's environment, with issues related to terrorism and job out sourcing, illustrates why this scenario is useful to consider in planning for the future.

LOOKING AHEAD IN THE FOOD WORLD

Today and in the future, the food system must be flexible and resilient, consumer driven, and sustainable, and it must secure the environment and natural resources and assure the health and wellness of an increasing number of consumers.

Food science and engineering can help us advance the food system, minimize risks, maximize benefits, and deliver a safe, nutritious, and abundant food supply to all people around the world.


Very Safe Foods
Better, Cheaper, and Faster Processes
Nutrient + Flavor + Functionality
What are we looking into?
As Natural as possible
Fresher than Fresh
Suitable Processes to Claim Finished Products are Organic

WHAT DO WE HAVE TODAY?

The impact of modern food manufacturing methods is evident in today's food supply.

Food quality can be maintained or even improved, and food safety can be enhanced.

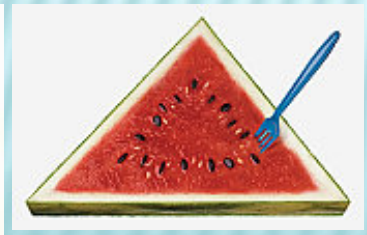
Sensitive nutrients can be preserved, important vitamins and minerals can be added, toxins and anti-nutrients (substances such as phytate that limit bioavailability of nutrients) can be removed, and foods can be designed to optimize health and reduce the risk of disease.

Waste and product loss can be reduced, and distribution around the world can be facilitated to allow seasonal availability of many foods.

Modern food manufacturing also often improves the quality of life for individuals with specific health conditions, offering modified foods to meet their needs (e.g., sugar-free foods sweetened with an alternative sweetener for people with diabetes).

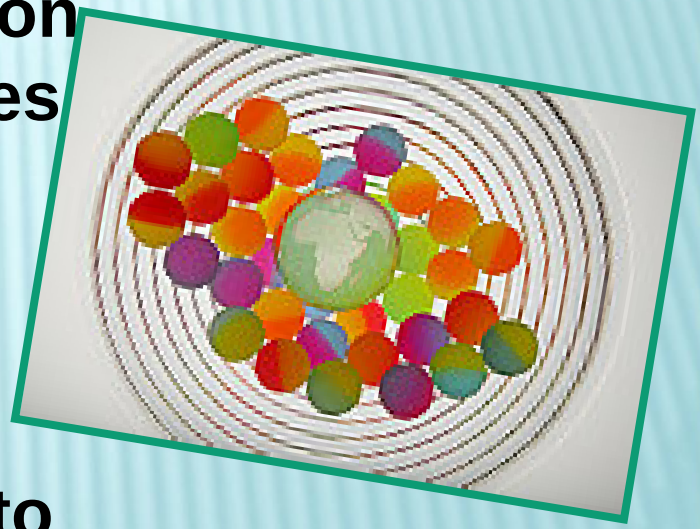
CHALLENGES to FOOD PROCESSORS

- Convenience foods
- Long lasting foods
- Premium products
- Ready-to-cook meals
- Low fat foods
- Foods for kids
- Ready-to-eat foods
- Foods for the undernourished
- Special foods for the ill
- Minimally processed foods
- Low carbohydrate foods
- Finger foods
- Space foods
- Combat rations



OVERCOMING THE CHALLENGES

- Seek safe processes
- Optimize raw ingredient utilization
- Work on energy saving strategies
- Identify adequate technologies
- Find efficient ways to store raw materials, semi finished and finished food products
- Identify packaging approaches to help in the marketing and preservation of foods



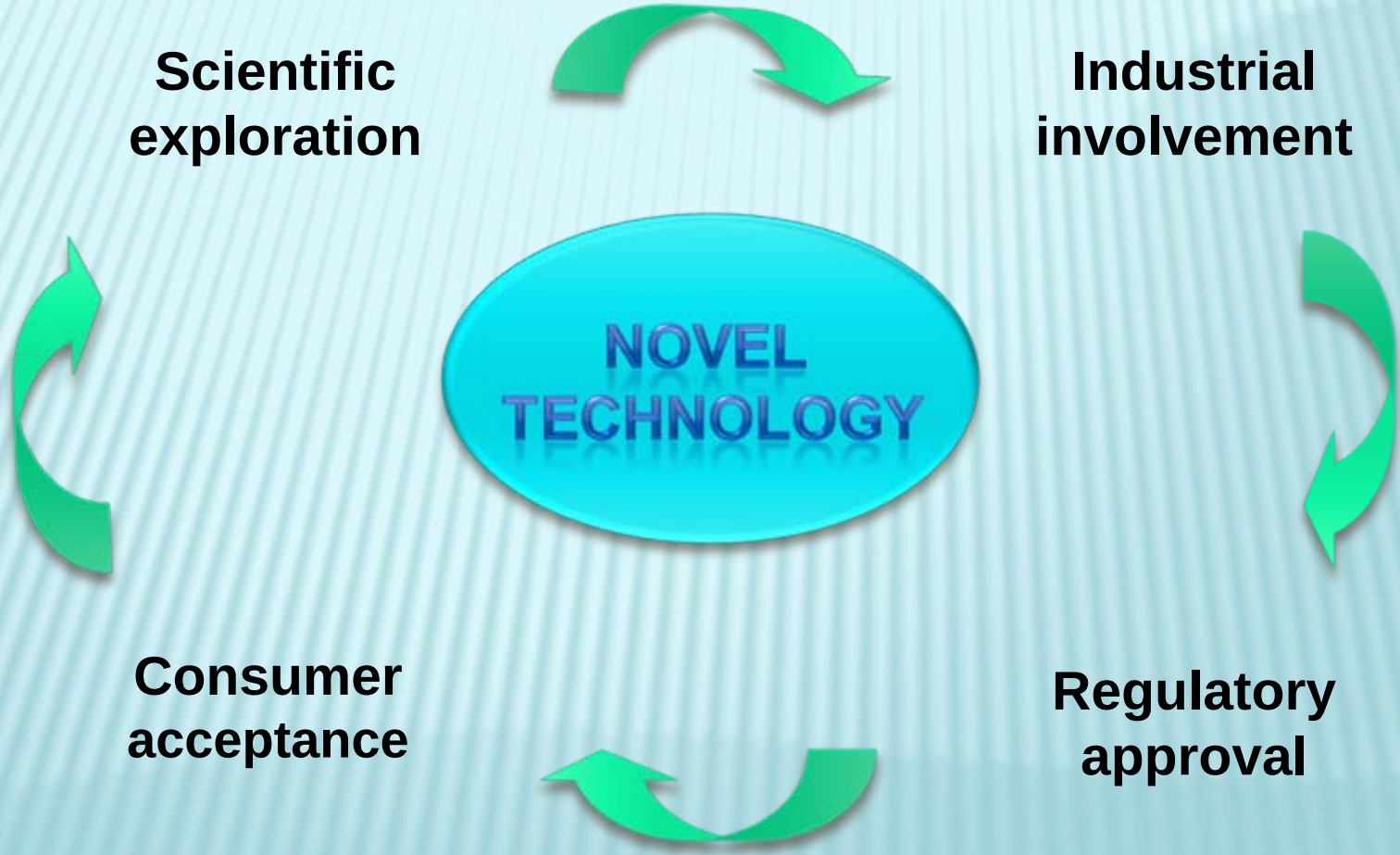
ONE OF THE BIGGEST CHALLENGES

Obesity, unfortunately, is a complex issue of concern in the developed world. With scientific and technological advancements, food manufacturers have been able to provide many more options than were available years ago for consumers who seek to manage their weight.

These options include food and beverage products with reduced caloric density and packaging as a component of portion control.

Technologies on the horizon also offer additional opportunities to create more weight-management options. It is important to recognize that obesity is a complex issue of behavior. Further developments in genomics, metabolomics, and nutrigenomics hold tremendous promise for development of individualistic solutions to obesity.

NEW INDUSTRIAL OPPORTUNITIES THROUGH NEW TECHNOLOGIES



POTENTIAL RESEARCH FIELDS FOR IMPROVING THE QUALITY OF PROCESSED FOOD

- Developing new thermal and nonthermal technologies
- Combining nutrition studies and nanoengineering to encapsulate useful nutrients in the processed food
- Predictive microbiology for safer foods and optimum quality
- Designing environmentally friendly (biodegradable) and informative (intelligent) or active packaging for processed food

Current Technological Issues under Consideration

Ingredients Modification

1- Decaffeination:

Conventional processes will be replaced by food biotechnology approaches and the application of microorganisms (bio-decaffeination) such as *Pseudomonas* species.

2- Fat Replacement

- **Using customized rather than general fat replacers for each product**

- **Developing the idea that not all fat should be replaced, because some fats have nutritional value (PUFAs)**

CURRENT TECHNOLOGICAL ISSUES UNDER CONSIDERATION

Ingredients Modification:

3- Enzyme Technology:

- Enzymes as biosensors
- Enzymes to form food flavors and aroma compounds
- Enzymes to monitor toxic chemical levels in food and water

4- Novel Food Biotechnology:

- Foods with viable organisms
- Foods produced from GMOs
- Foods with ingredients produced by GMMs
- Foods with ingredients processed by enzymes from GMMs

CURRENT TECHNOLOGICAL ISSUES UNDER CONSIDERATION

Ingredients Protection and Delivery Control:

1- Encapsulation

Strategy for keeping vitamins, nutrients, and sensitive materials in food from being inactivated or lost during processing.
e.g. Encapsulation of fish oils (containing omega 3) provides a means of protection against oxidation

2- Nano Technology:

1. **Nanoemulsion, Nanoparticles, Nanocomposites (Materials)**
2. **Nanosensor, Nanotracers (Food Safety)**
3. **Nanobiotechnology, Nanoscale reaction engineering (Processing)**
4. **Delivery, Formulation, Packaging (Product)**

PREDICTIVE MICROBIOLOGY

- **Establishing mathematical and probabilistic models for predicting the microbial contamination and risk assessment in different temperatures, pHs, salt concentration, etc.**

- **Unlike most conventional thermal food processing methods, new technologies (e.g. PEF, HHP,US) do not follow the first order reaction. Consequently, new models are required for emerging technologies (e.g. Weibull Model) to establish microbial destruction studies; these are more complicated models with concave upward or downward shapes.**

- **Some new mathematical models and computer software (e.g.** ComBase) **are used to predict the probability of a pathogen presence in the product as well as removing the need for repetition of experiments.**

DEVELOPING EMERGING THERMAL AND NONTHERMAL TECHNOLOGIES

NONTHERMAL PRESERVATION OF FOODS

Ultrasound, Ultraviolet, High hydrostatic pressure, Pulsed electric fields

NEW THERMAL PROCESSING METHODS

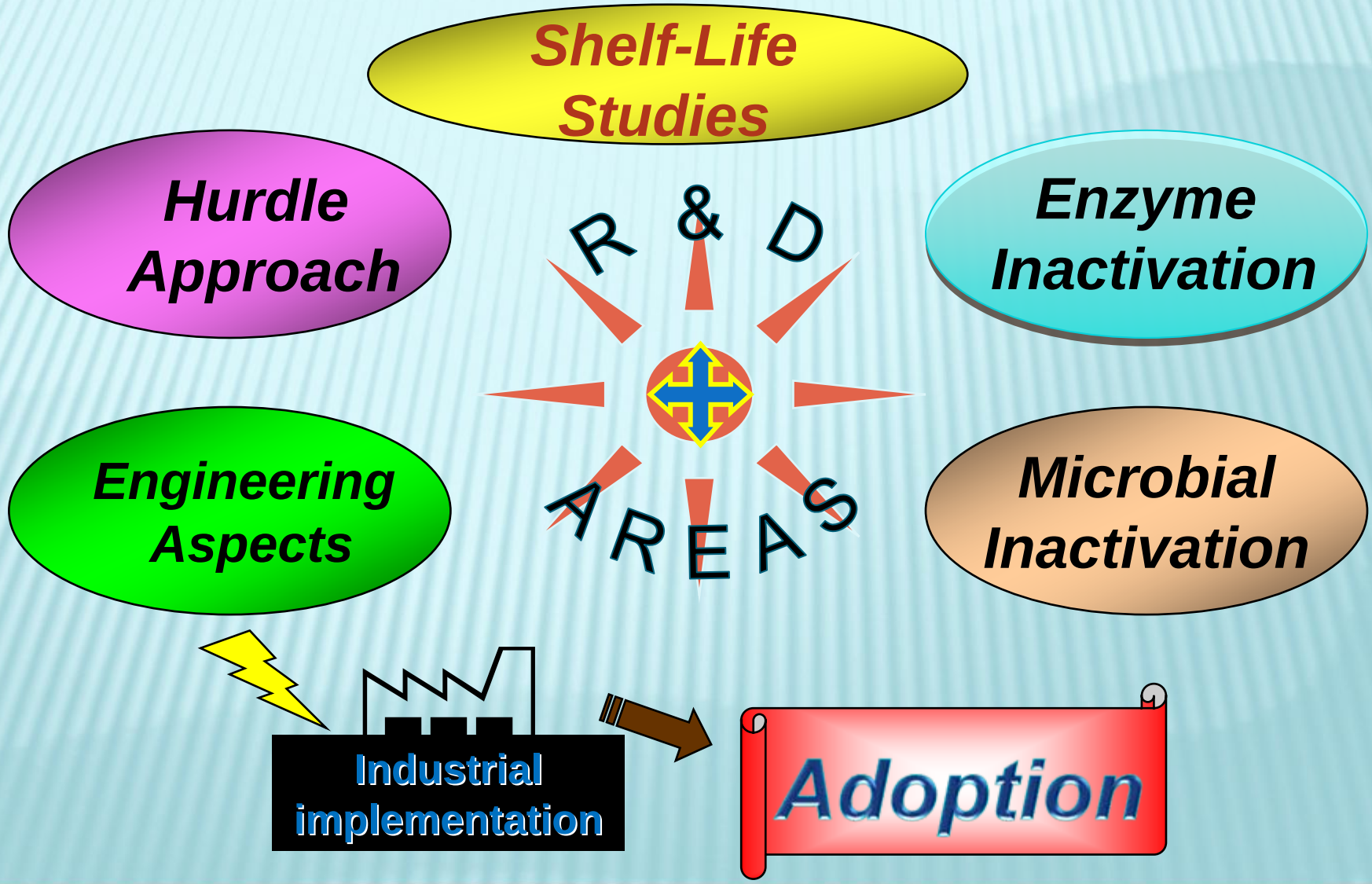
Microwave processing , Ohmic heating, Radio frequency

SOME POTENTIAL USES OF THESE TECHNOLOGIES

HHP as a post-packaging lethality step for the inactivation of microorganisms in some conventional food processing

Combination of HHP and Temperature for inactivating spores

ADOPTATION OF NEW TECHNOLOGIES



ASSESSMENT DERIVED FROM NASA SCALE

TECHNOLOGY READINESS LEVELS *

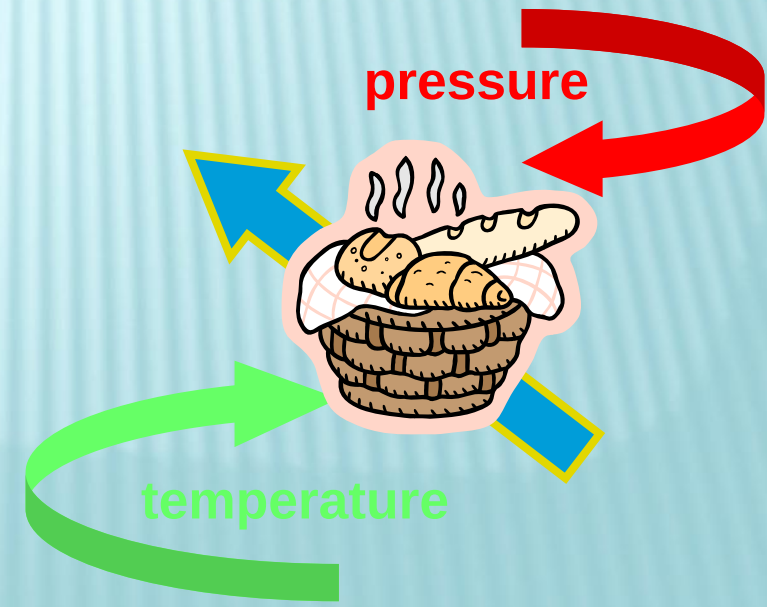
BASIC RESEARCH	1. BASIC PRINCIPLES OBSERVED AND REPORTED
RESEARCH TO PROVE FEASIBILITY	2. TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED
TECHNOLOGY DEVELOPMENT	3. ANALYTICAL AND EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT
	4. COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT
TECHNOLOGY DEMONSTRATION	5. COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT
	6. SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (GROUND OR SPACE)
SYSTEM DEVELOPMENT	7. SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT
SYSTEM TEST/ OPERATIONS	8. ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION
	9. ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

* From SSP 50198 (11/22/95)

HIGH PRESSURE AS A STERILIZATION PROCESS

- High Pressure Thermal Sterilization (HPTS)
- Combination of pressures and temperatures
  - + Vegetative cell inactivation
  - + Bacterial spore inactivation
  - + Minimal thermal degradation
- Foods with superior quality attributes

HP-35 L
Sterilization Unit

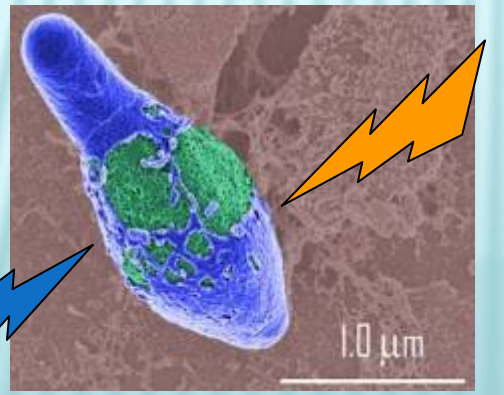


HIGH PRESSURE AS A STERILIZATION PROCESS

- **Combination of pressures (600-800 MPa) and temperatures (60-90°C)**
  - **Vegetative cell inactivation**
  - **Bacterial spore inactivation**
  - **Minimal thermal degradation**
- **Foods with superior quality attributes**

IMPROVED QUALITY

temperature



Clostridium botulinum spore

HPTS: PROCESSING STEPS

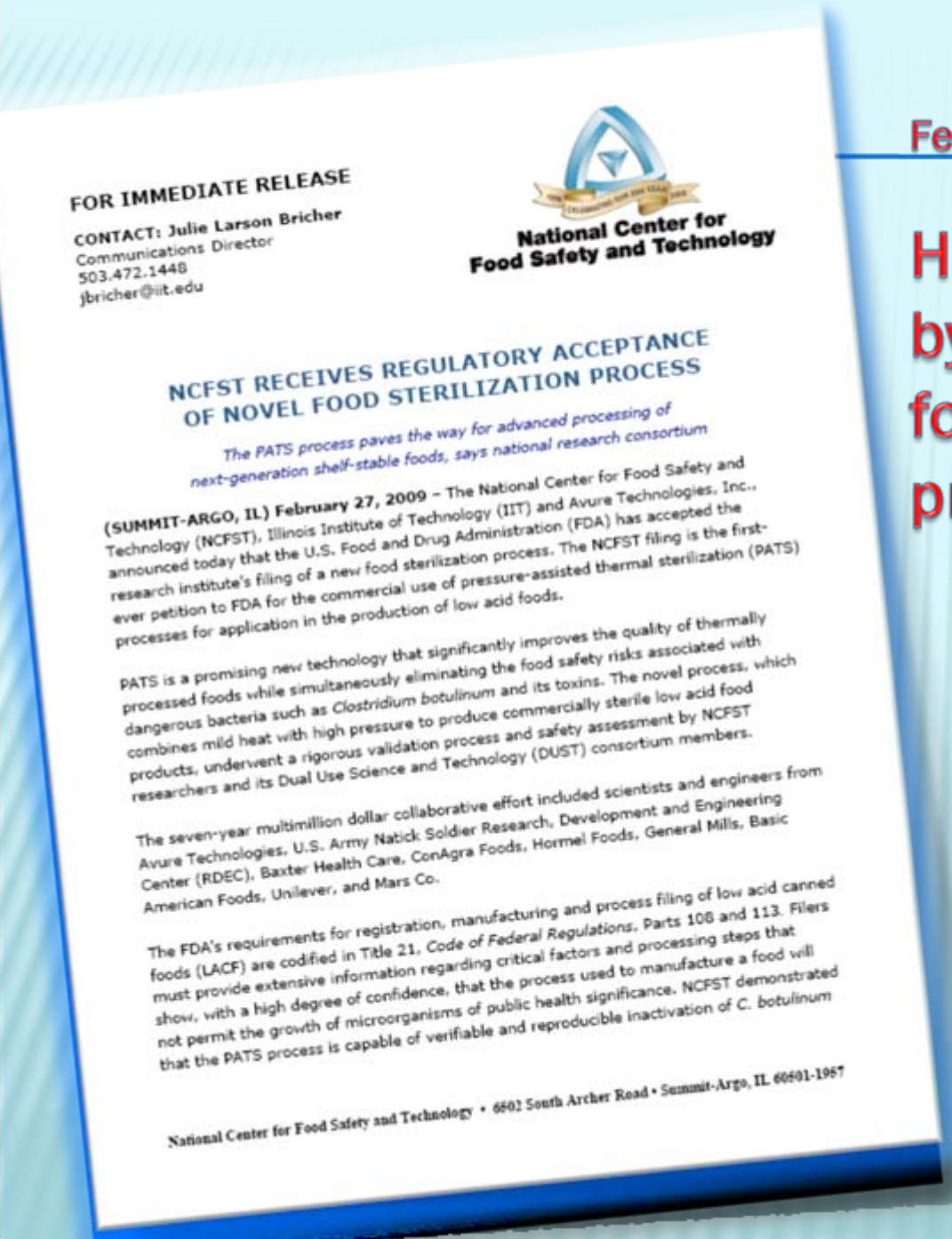
Vac, pack & load

Preheating

Thermal pressurization

Unload

Cooling



FOR IMMEDIATE RELEASE

CONTACT: Julie Larson Bricher
Communications Director
503.472.1448
jbricher@iit.edu

National Center for Food Safety and Technology

NCFST RECEIVES REGULATORY ACCEPTANCE OF NOVEL FOOD STERILIZATION PROCESS

The PATS process paves the way for advanced processing of next-generation shelf-stable foods, says national research consortium

(SUMMIT-ARGO, IL) February 27, 2009 – The National Center for Food Safety and Technology (NCFST), Illinois Institute of Technology (IIT) and Avure Technologies, Inc., announced today that the U.S. Food and Drug Administration (FDA) has accepted the research institute's filing of a new food sterilization process. The NCFST filing is the first-ever petition to FDA for the commercial use of pressure-assisted thermal sterilization (PATS) processes for application in the production of low acid foods.

PATS is a promising new technology that significantly improves the quality of thermally processed foods while simultaneously eliminating the food safety risks associated with dangerous bacteria such as *Clostridium botulinum* and its toxins. The novel process, which combines mild heat with high pressure to produce commercially sterile low acid food products, underwent a rigorous validation process and safety assessment by NCFST researchers and its Dual Use Science and Technology (DUST) consortium members.

The seven-year multimillion dollar collaborative effort included scientists and engineers from Avure Technologies, U.S. Army Natick Soldier Research, Development and Engineering Center (RDEC), Baxter Health Care, ConAgra Foods, Hormel Foods, General Mills, Basic American Foods, Unilever, and Mars Co.

The FDA's requirements for registration, manufacturing and process filing of low acid canned foods (LACF) are codified in Title 21, *Code of Federal Regulations*, Parts 108 and 113. Filers must provide extensive information regarding critical factors and processing steps that show, with a high degree of confidence, that the process used to manufacture a food will not permit the growth of microorganisms of public health significance. NCFST demonstrated that the PATS process is capable of verifiable and reproducible inactivation of *C. botulinum*

National Center for Food Safety and Technology • 6502 South Archer Road • Summit-Argo, IL 60501-1957

February 27, 2009

HPTS has been accepted by the FDA for food sterilization processes

FDA

AVURE TECHNOLOGIES

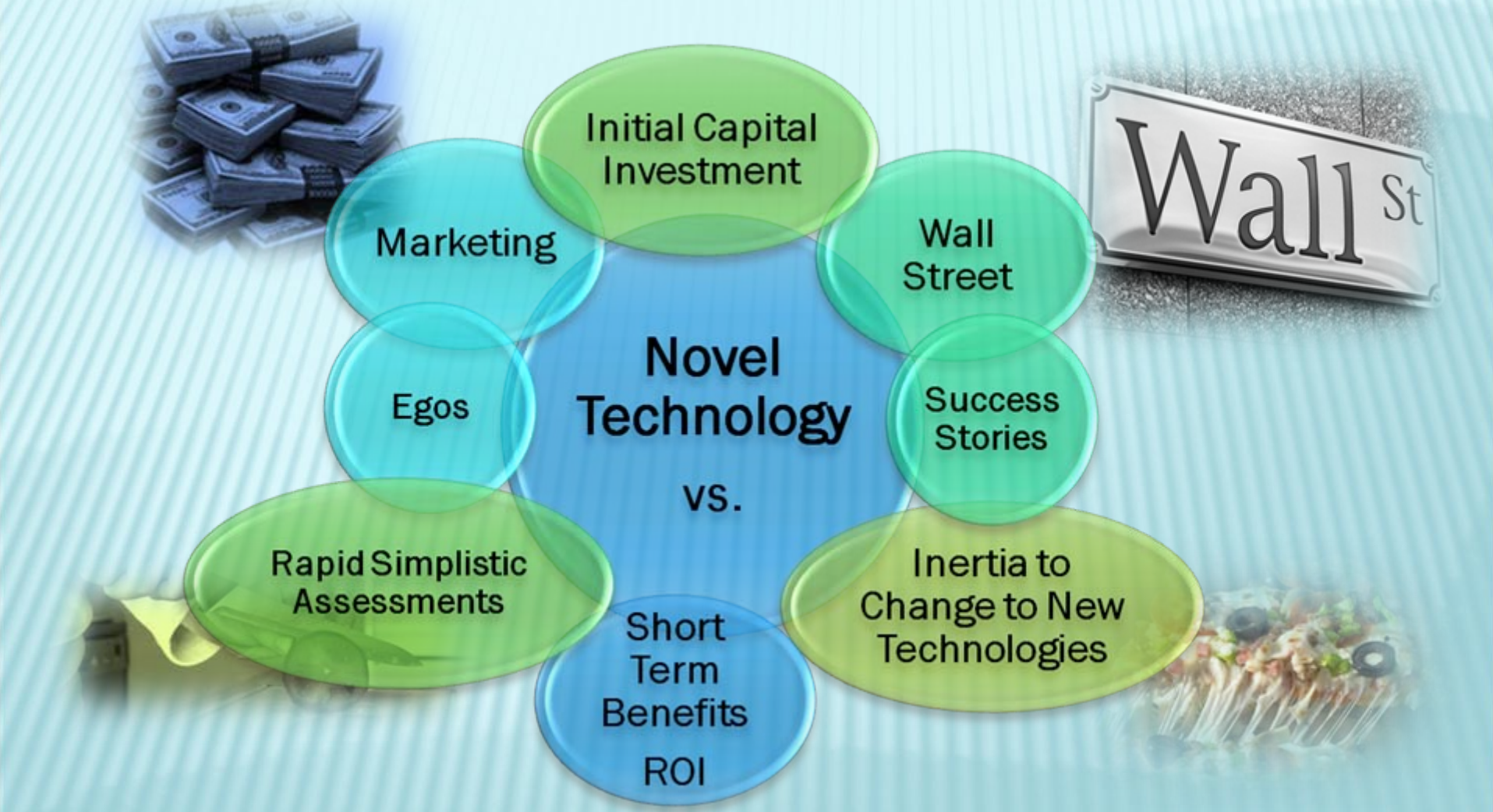
National Center for Food Safety and Technology

COMBINING NUTRITION STUDIES WITH ENGINEERING (Nutrition Process Engineering)

The idea

1. Treating the gastrointestinal tract as a chemical reactor.
2. Digestion and absorption processes can be quantitatively calculated through collaborative study of engineering, biochemistry, and physiology.
3. Mathematical modeling of gastrointestinal tract will help nutritionist predict response of body to food.

The Quest for Novel Technology Adoption



PACKAGING INTEGRATION TO THE PROCESSING OF FOODS

- **ACTIVE PACKAGING**

  Employs packaging material that interact with the environment to extend the shelf-life of food.

  Examples: *Oxygen scavenging, Carbon dioxide production*

  Potential types: Add either an anti-microbial substance or specific type of component capable to react with released gas inside the package to produce a desired atmosphere.

- **INTELLIGENT PACKAGING**

  1- A conventional package made smart by **RFID** for tracking it

  2- A package made smart by functional attributes

  that satisfy consumer's benefit.

  Example: *Time-temperature food quality labels*

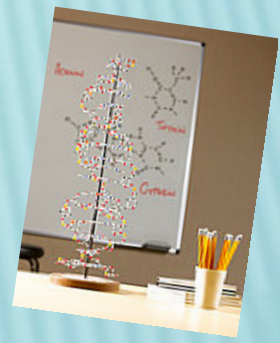
BIODEGRADABLE PACKAGING

➢**PROBLEM!** **Poor barrier properties and weak mechanical properties**

1. **Blend with other synthetic polymers**
2. **Chemical modification**

OR

3. **Add appropriate nanoparticles**



FINAL REMARKS

- The future focus of food engineering will be on consumer health and safety

- To intelligently use emerging thermal and nonthermal technologies like Microwave, Ohmic heating, Pulsed electric fields, High hydrostatic pressure, etc., to pasteurize and sterilize foods should be encouraged to offer quality foods

FINAL REMARKS

- **Packaging has a specific role in preserving the quality of the final product therefore the integration of packaging as part of the processing of foods should be emphasized.**

- **New alternative methods for modification of food composition, such as decaffeination, should be considered to offer healthier food**

- **Additionally, the role of some common additives in food processing, like enzymes, should be expanded**

CONCLUDING REMARKS

Food science and engineering professionals must work together with many others and society must invest in basic and applied research and education and outreach.

With science and technology solutions available to address specific issues throughout the food system, our ability to feed a growing population in a sustainable way, while safeguarding both human and planet health, looks not only possible, but also promising.

We must, however, remain steadfast and rational about our approach, to help both humanity and nature.


MUCHAS GRACIAS