



Sustainable, Safer and Healthier Food Production: Issues and Emerging Technologies

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Food Engineering and Bioprocess Technology



Our Health in Our Vision



1. Why do we eat when we eat

- Comfort, culture
- Satisfy a psychological need

2. Why do we eat what we eat

- Convenience
- Connectivity
gender, age, life-style, income
- Individualism
- Homing
High quality ready-to-eat products
- Sensory adventure
Experience of new tastes and innovation
- Health
Functional food with specific health benefits





Food for thought!



We're growing

Over 1 billion people are obese or overweight



We're growing older

Increasing prevalence of diseases and Development of functional disabilities



We're getting concerned

Food is a key topic for consumers with respect to health



We're getting unhealthier

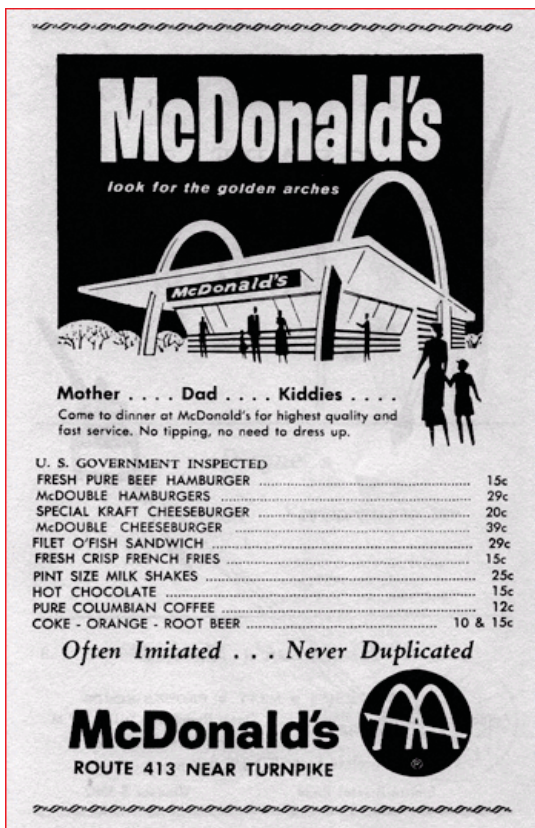
All signs are turning red, but we know it and we are willing to spend

TRENDS CHANGING IN FOOD INDUSTRY

From 'easy eating-out'

To 'SuperSizing'

...To 'I'm loving it'...
'Taste, Choice, Vitality'.



50's



90's



current

Courtesy: DSM

How does food become ‘functional’

- Changing food habits to natural types of food products – eg, fruits, vegetables, grains, fish)
- Formulated foods enriched with ‘functional’ ingredients (fortifying foods with active ingredients)
- Alteration of composition of whole foods to enhance beneficial components
 - Breeding techniques
 - Animal’s diet
 - Genetic engineering

Future Processing Trends

Traditional Technologies

Vs

Novel Technologies

↓
Improvements in Designs and Controls
Redesign
↓
Improved Manufacturing Performance



↓
Novel Processes
↓
Transformation & Preservation
↓ ↓
Improved Quality Products

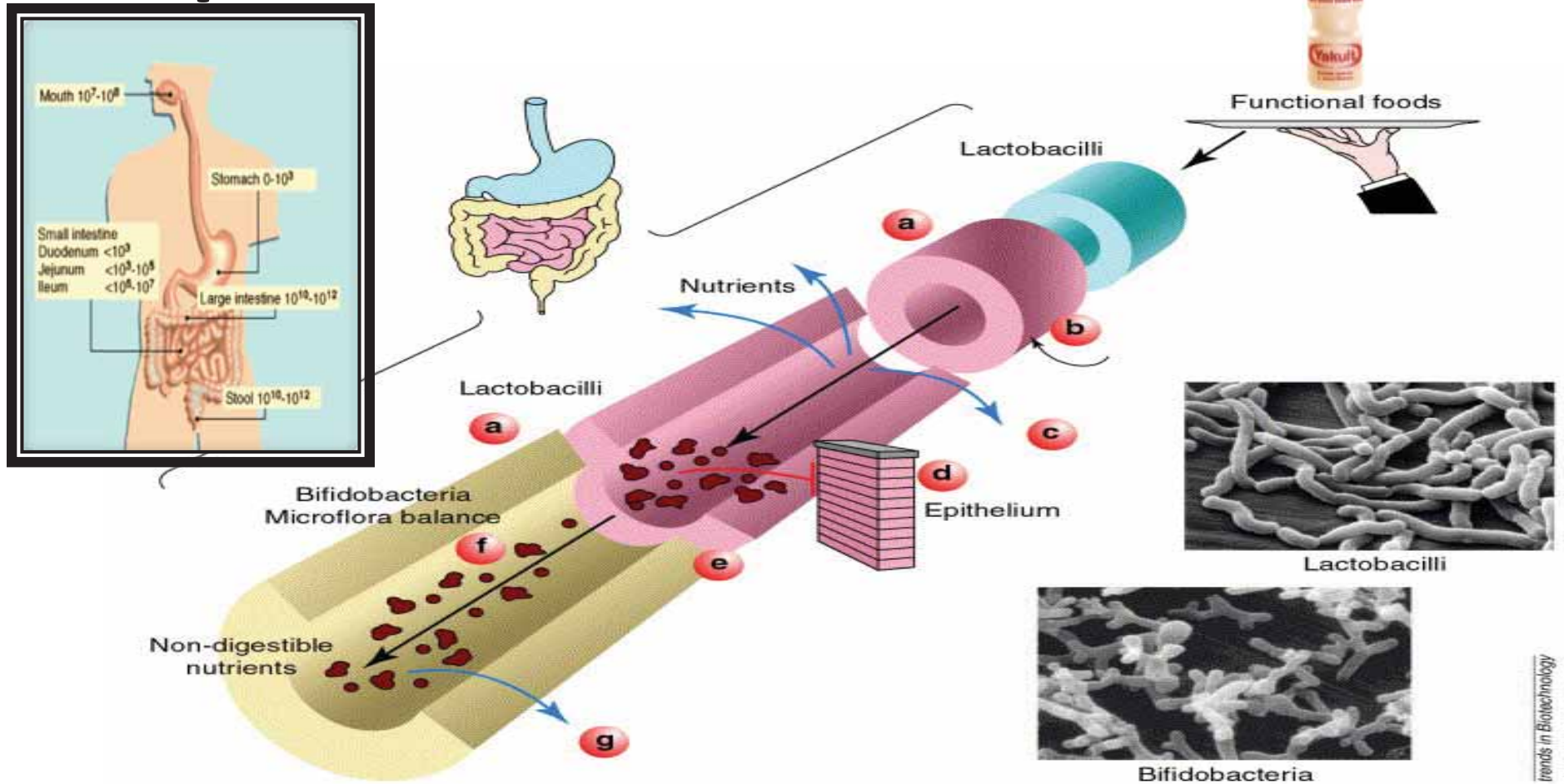
↓
Improved Product Quality



↓
Traditional Foods

↓
Novel Foods

Probiotics as Functional Component in Foods



Live microbial feed supplements that have beneficial effects on the host by improving its intestinal microbial balance.



Functional Probiotic Foods





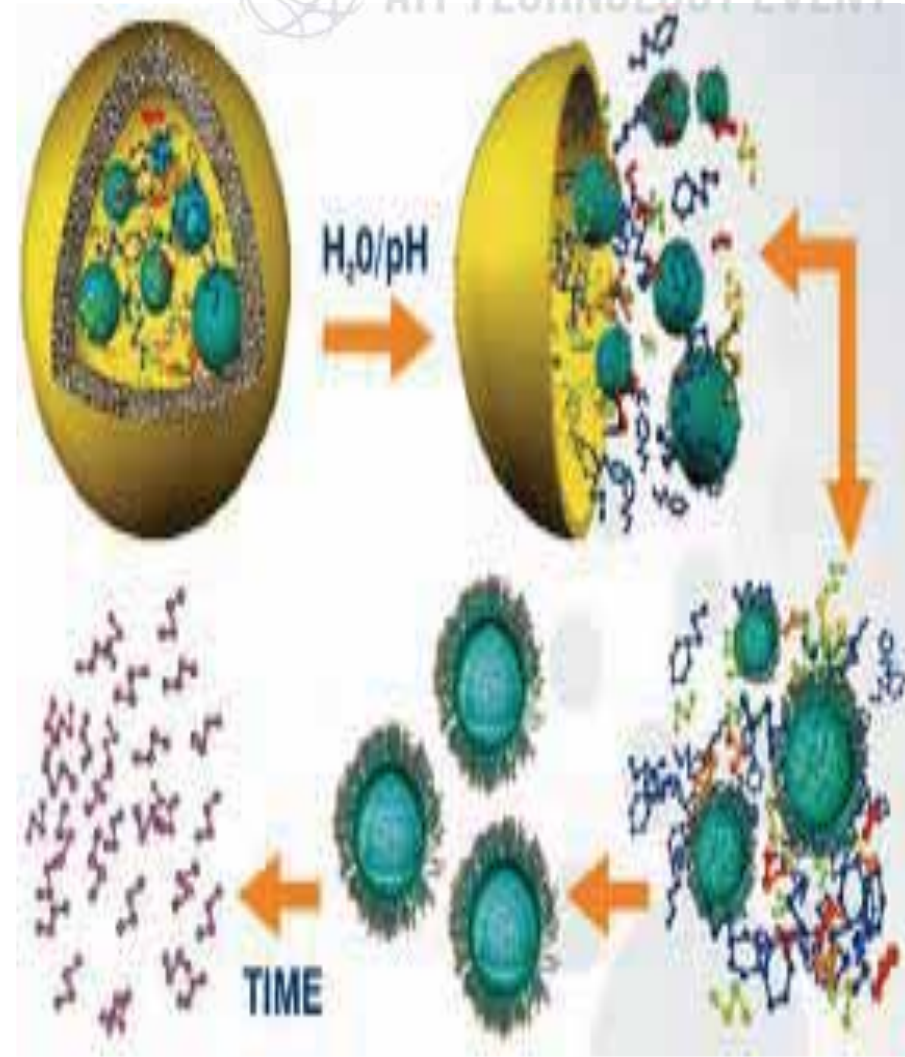
Customized Biocapsules: From Multilayers to Smart Containers for Delivery of LIVE CELLS and Bioactive Compounds



- **Bioencapsulation**

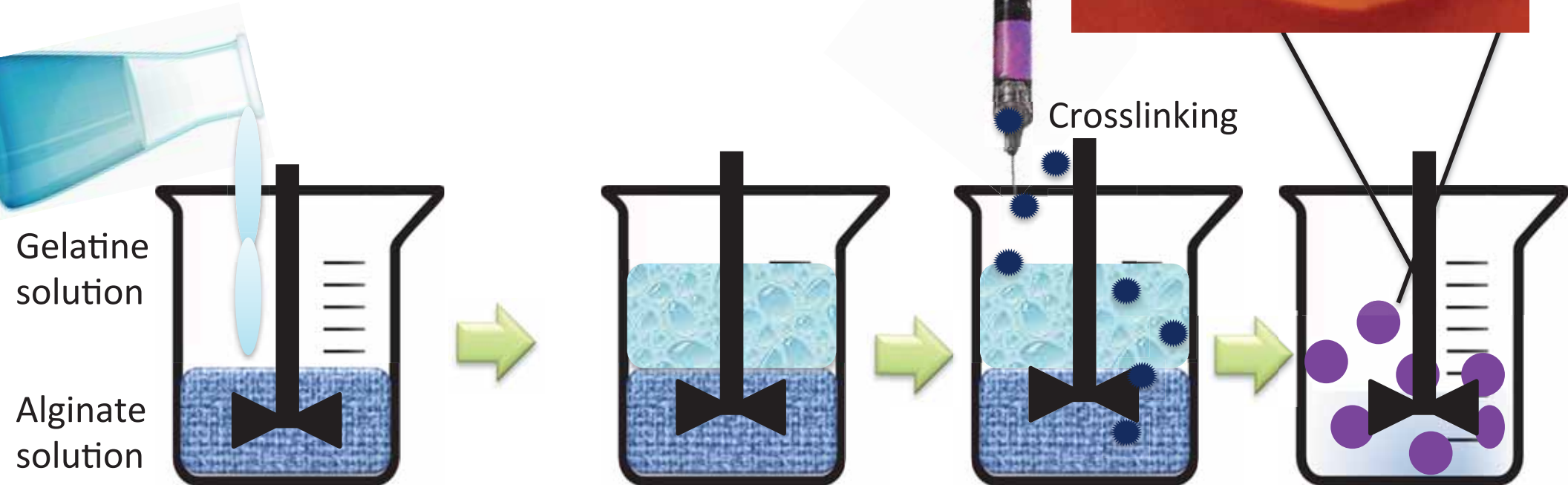
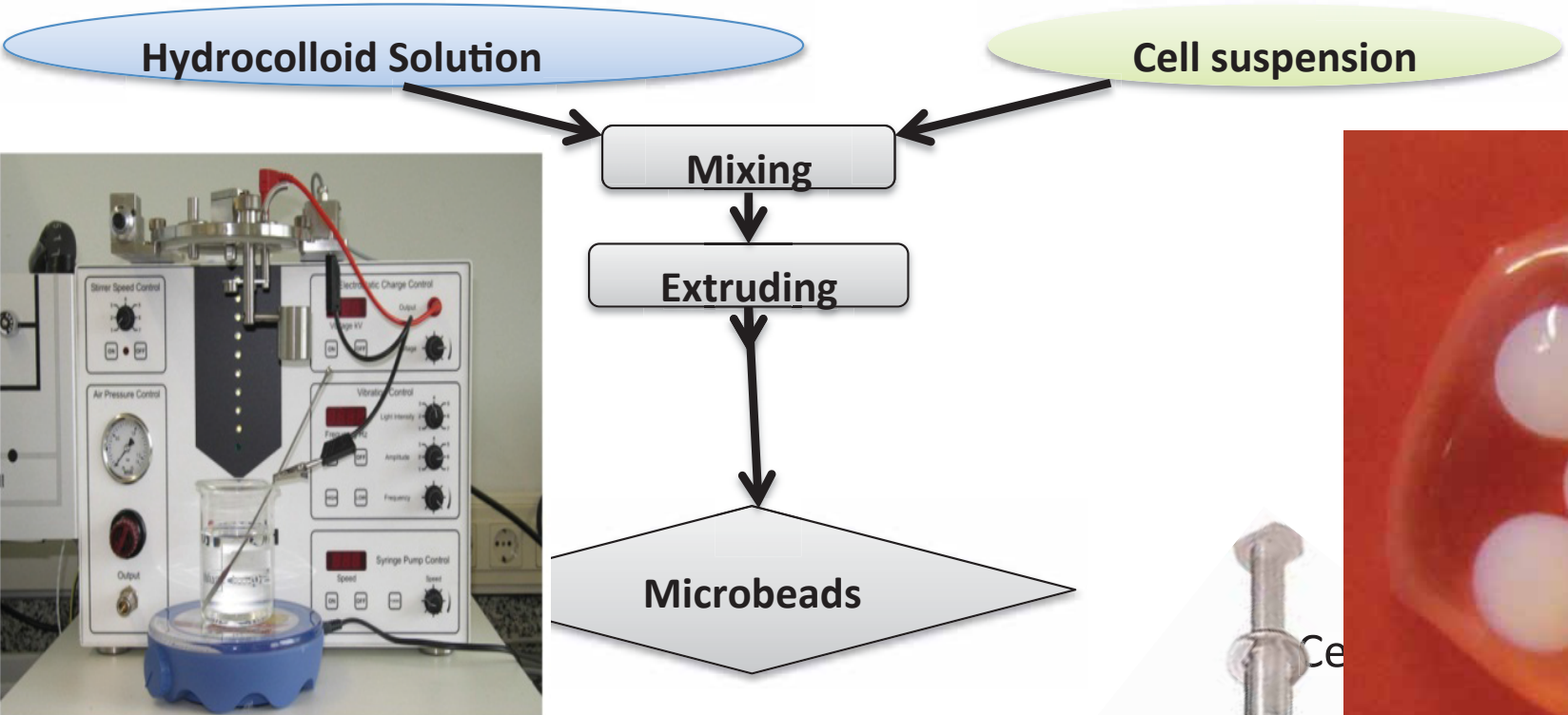
Process in which tiny particles or droplets are surrounded by coating to give small capsules.

- The material inside the microcapsule is referred to as **the core**, internal phase, whereas the wall is called a **shell, coating or membrane**.

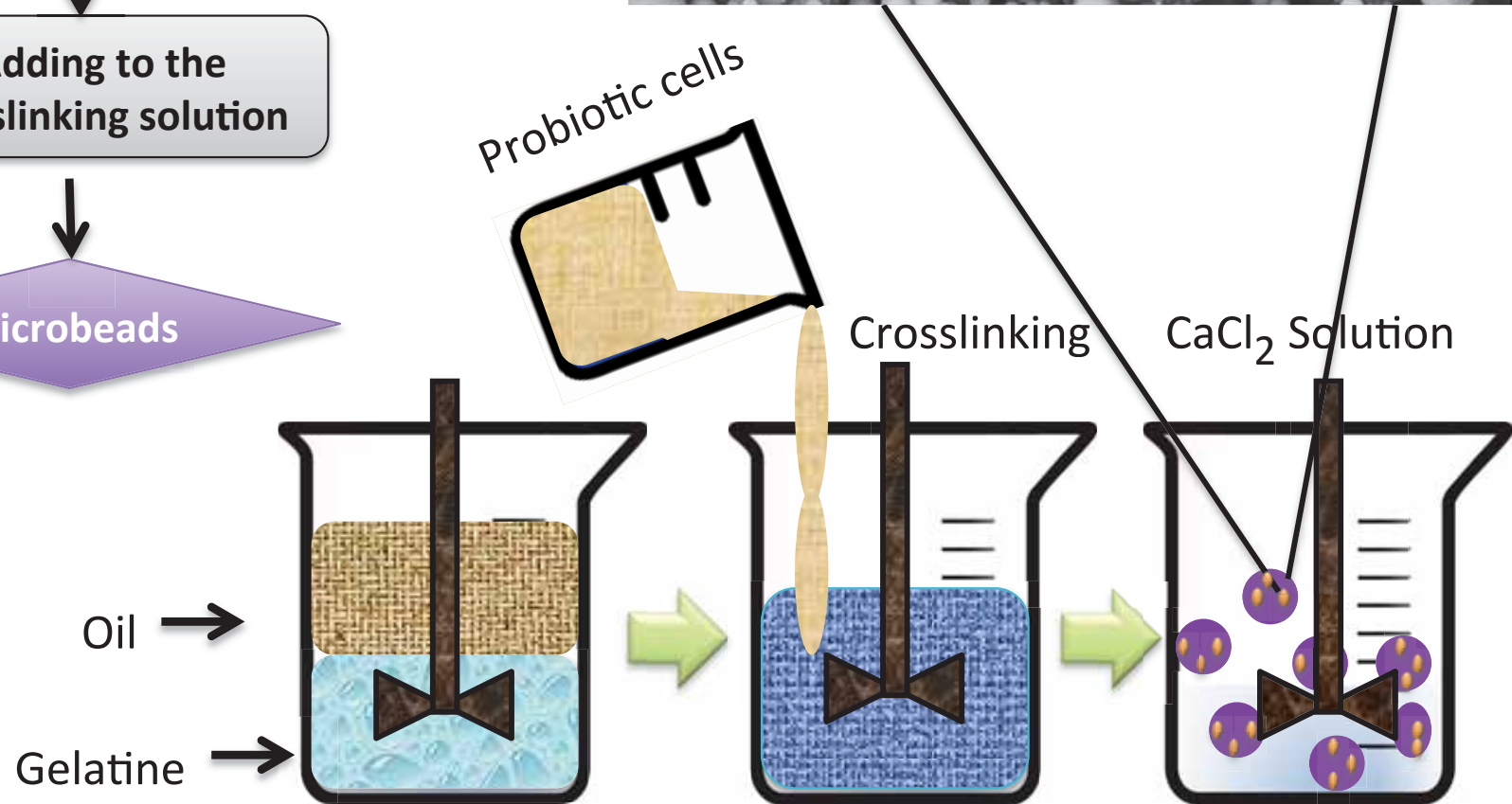
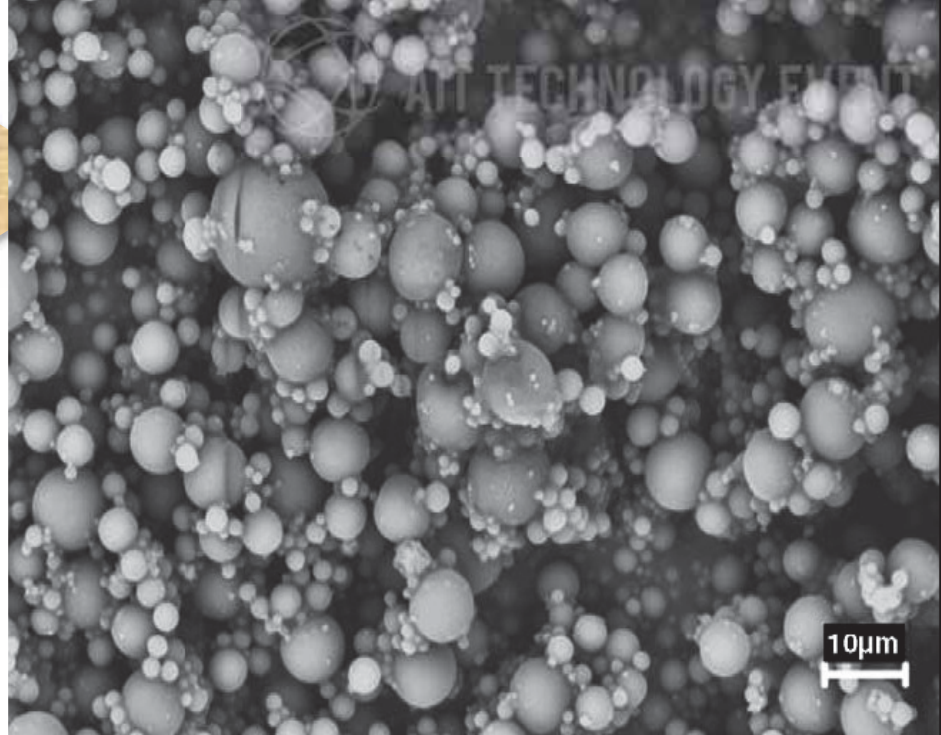
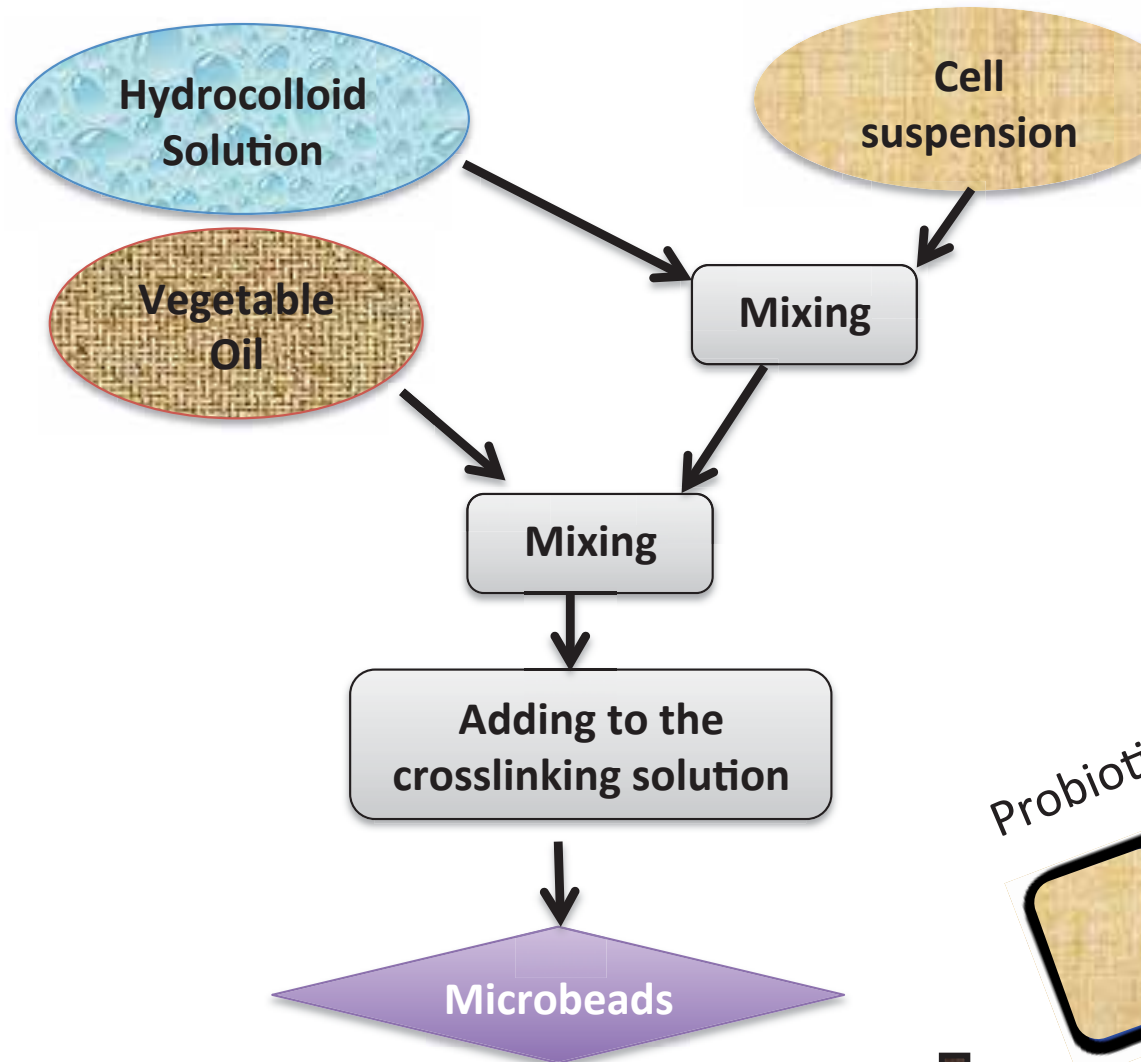


Extrusion

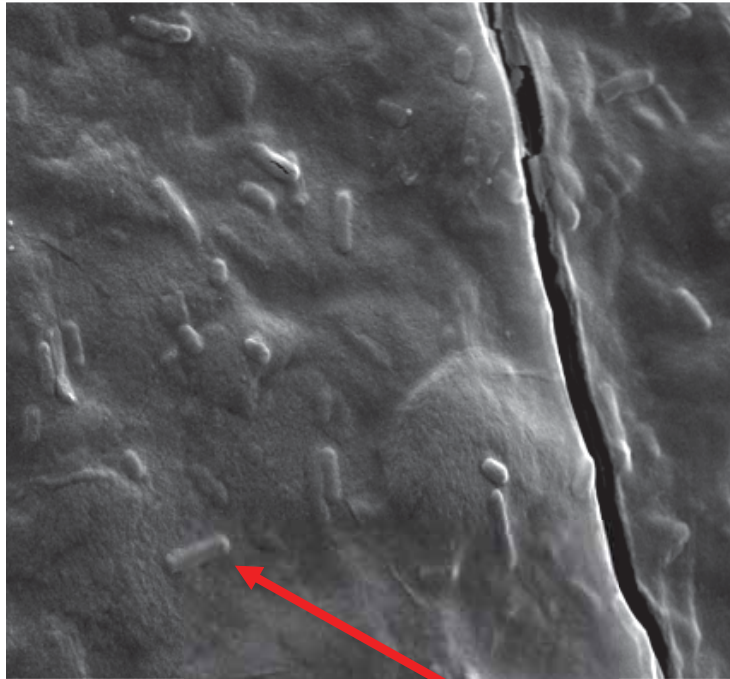
Y FANG, KS HAN, Anil K. Anal, H. Singh (2012)
WO Patent 2,012,142,153, 2012/US Pat 20,120,263,826, 2012



2. Emulsification

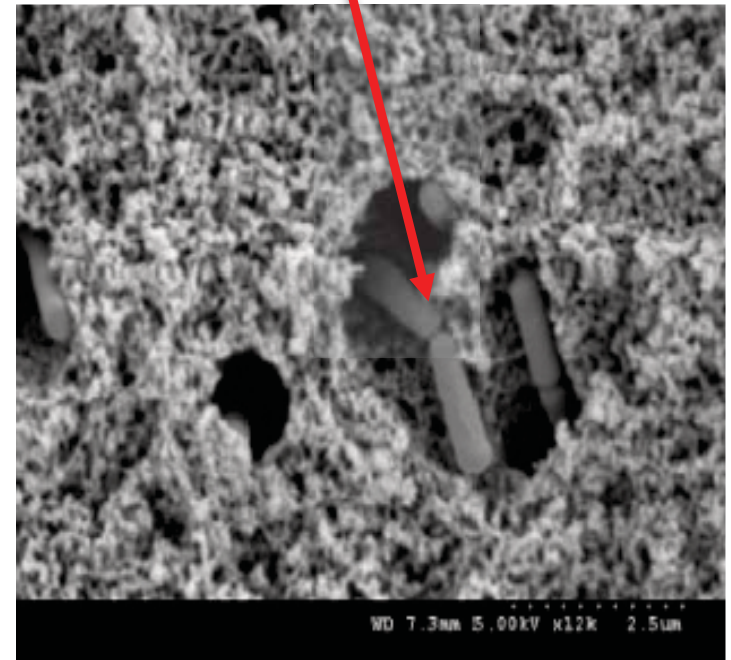


Capsule Morphology

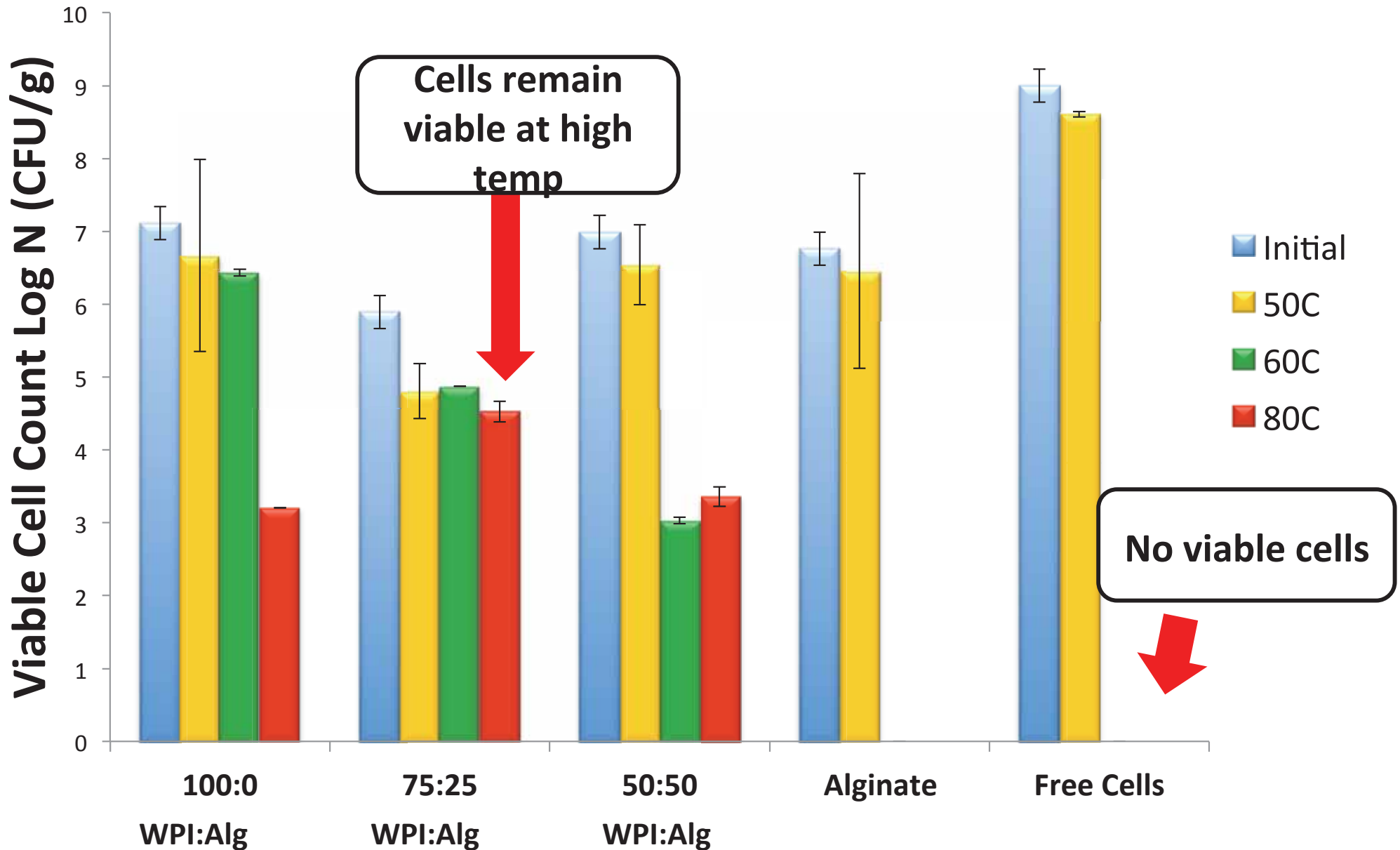


L. acidophilus cells under surface of capsule

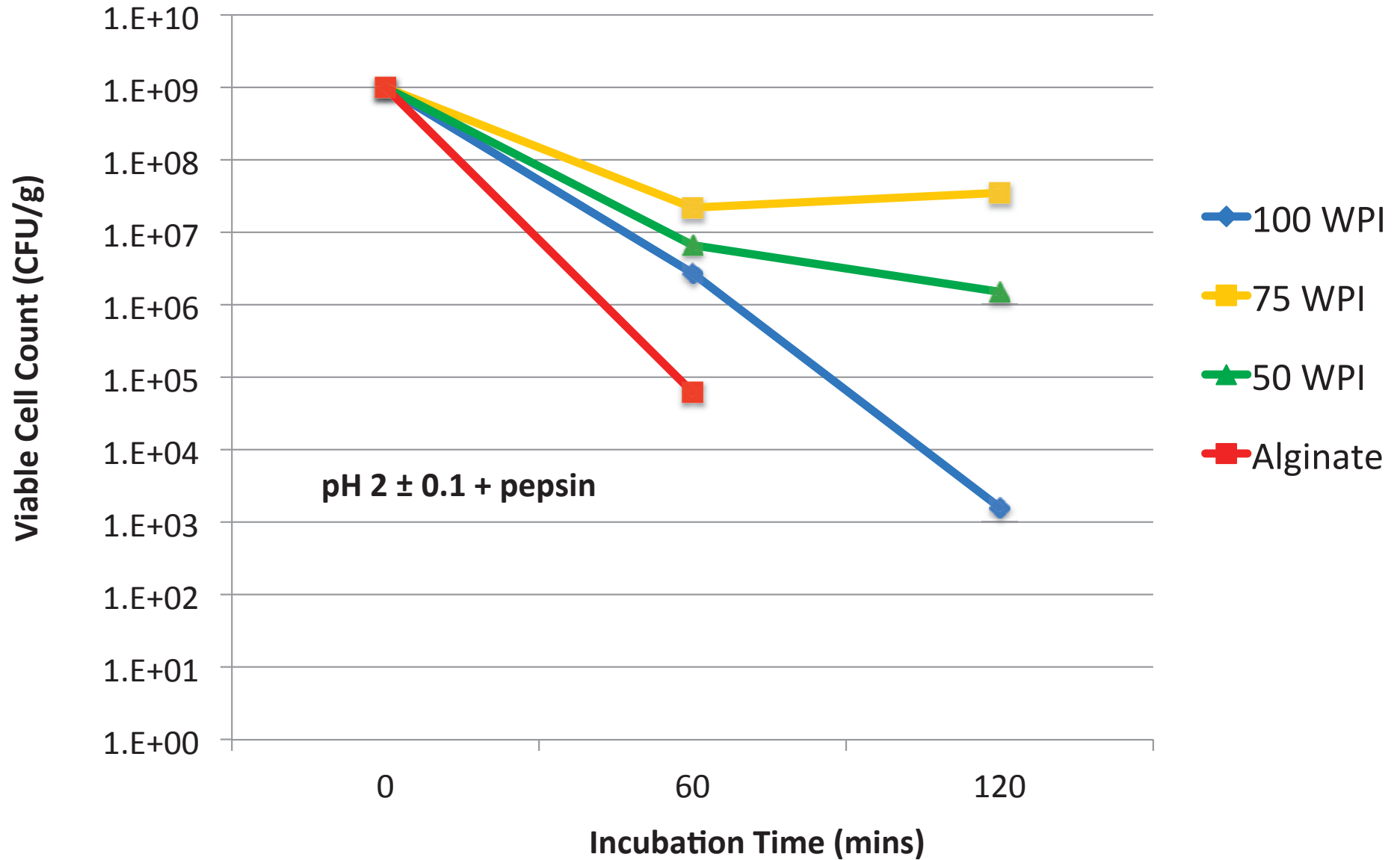
L. acidophilus cell embedded in WPI matrix



Viability Cell Count of *L. acidophilus* Following Heat Treatment

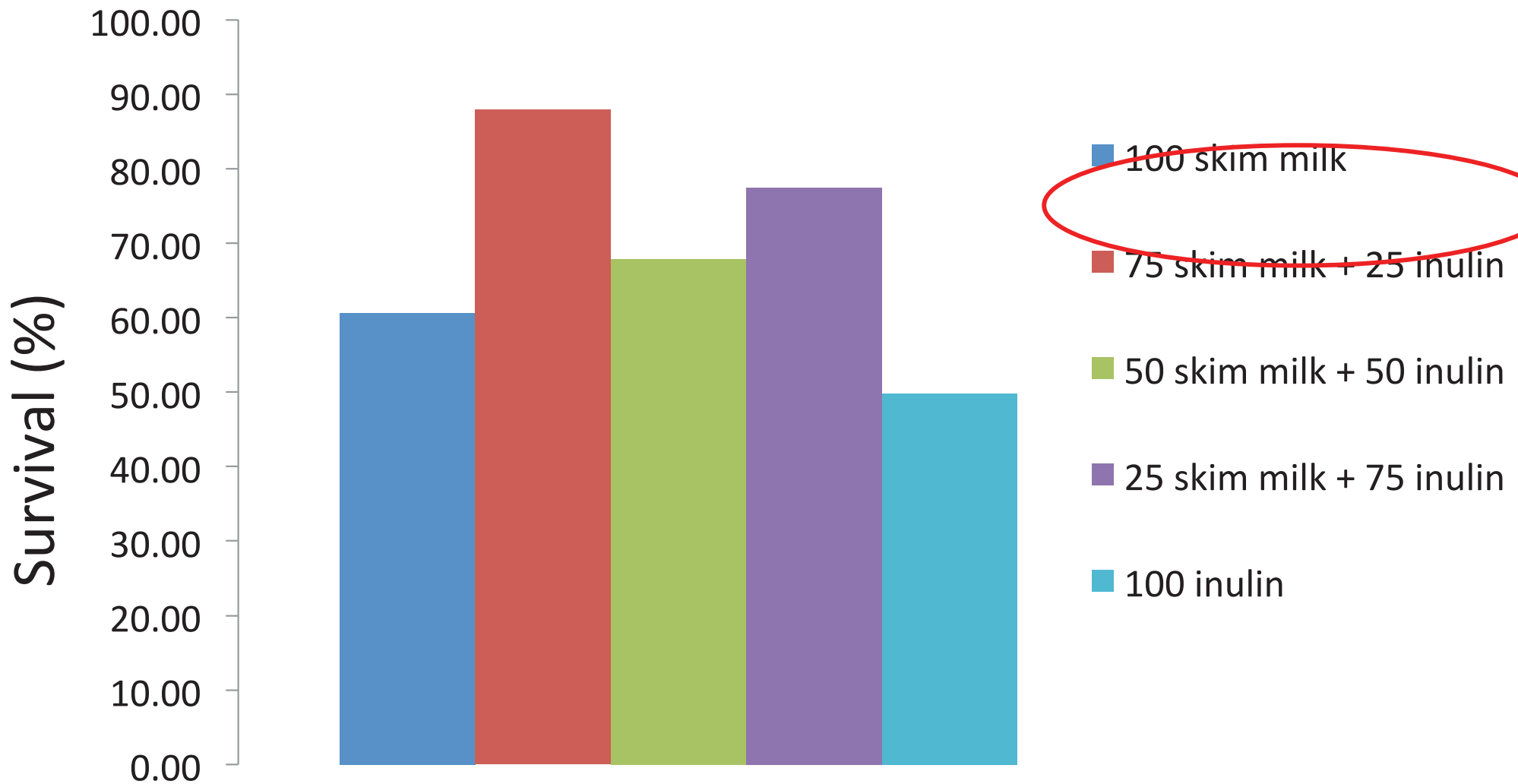


Viable Cell Count of entrapped *L. acidophilus* Following Incubation in SGF





Freeze drying probiotic powder made with skim milk and inulin at different ratios For preparation of **Probiotic coffee**





Augmentation of Natural **Folate via Fermentation** with *Probiotics* in Dairy and Non-dairy (Soy-based) products

PAB

A

**125($\mu\text{mol/l}$) optimum condition
-21.87 $\mu\text{g}/100\text{ml}$**

**110% higher folate than normal
milk**

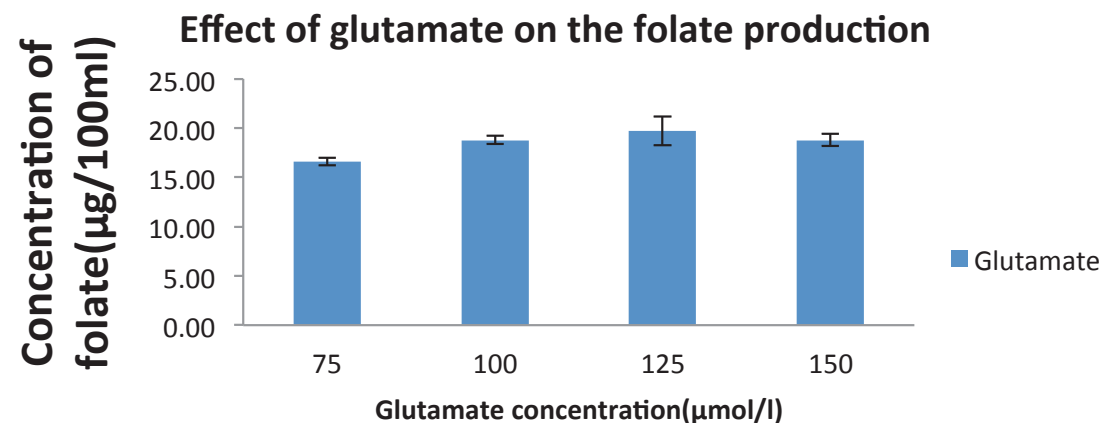
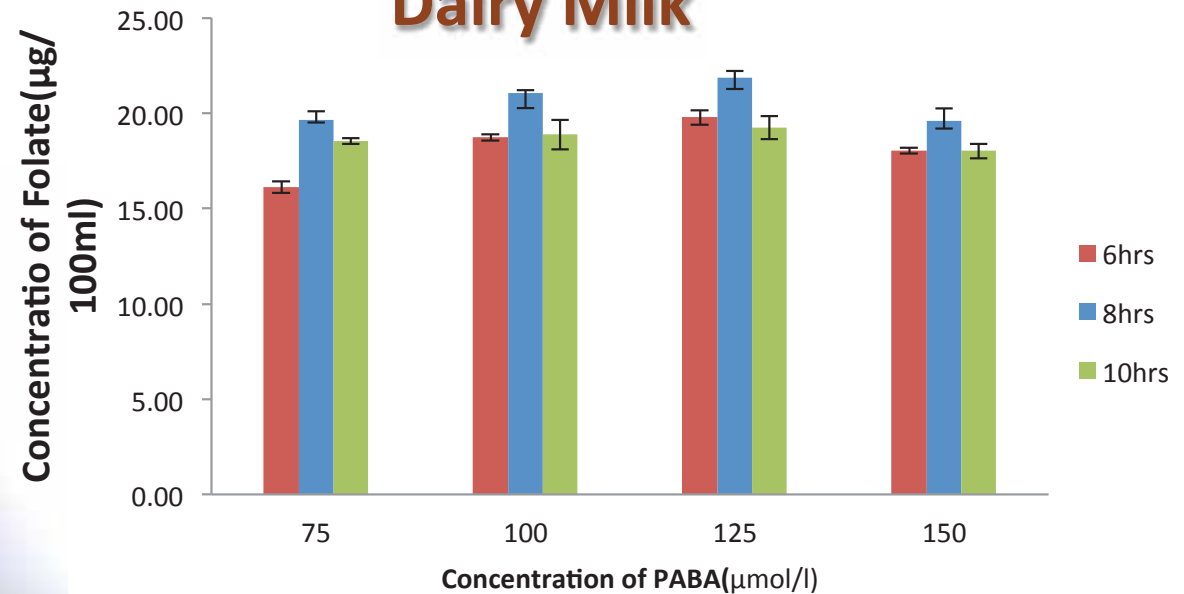
24 % higher than fermented milk

Glutamate

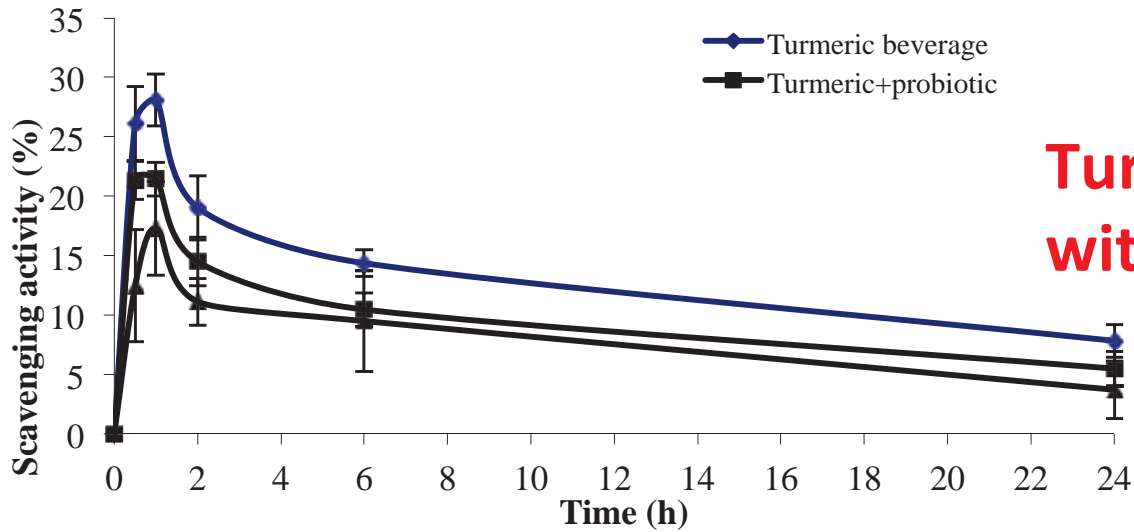
**125($\mu\text{mol/l}$) optimum
condition-19.74 $\mu\text{g}/100\text{ml}$**

**31.4% increased than
fermented milk**

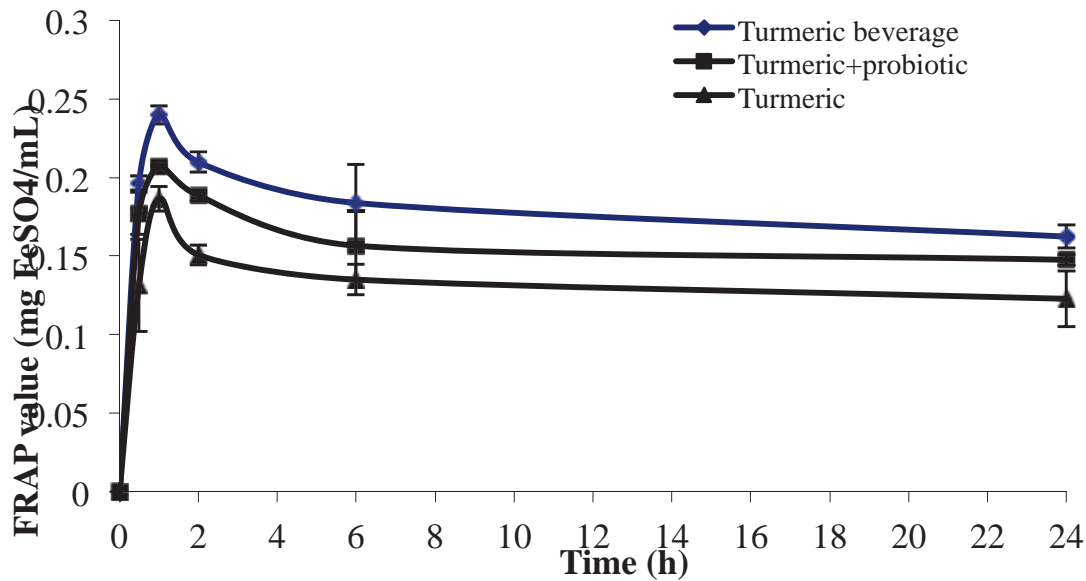
Dairy Milk



Turmeric Beverage fermented with Probiotics (Rat Study)



Scavenging activity (%) value of turmeric beverage, turmeric powder with probiotic and turmeric powder only in rat plasma after a single oral administration of the sample (250 mg/kg body weight).

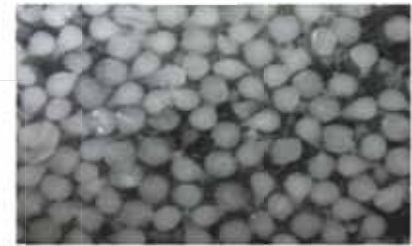
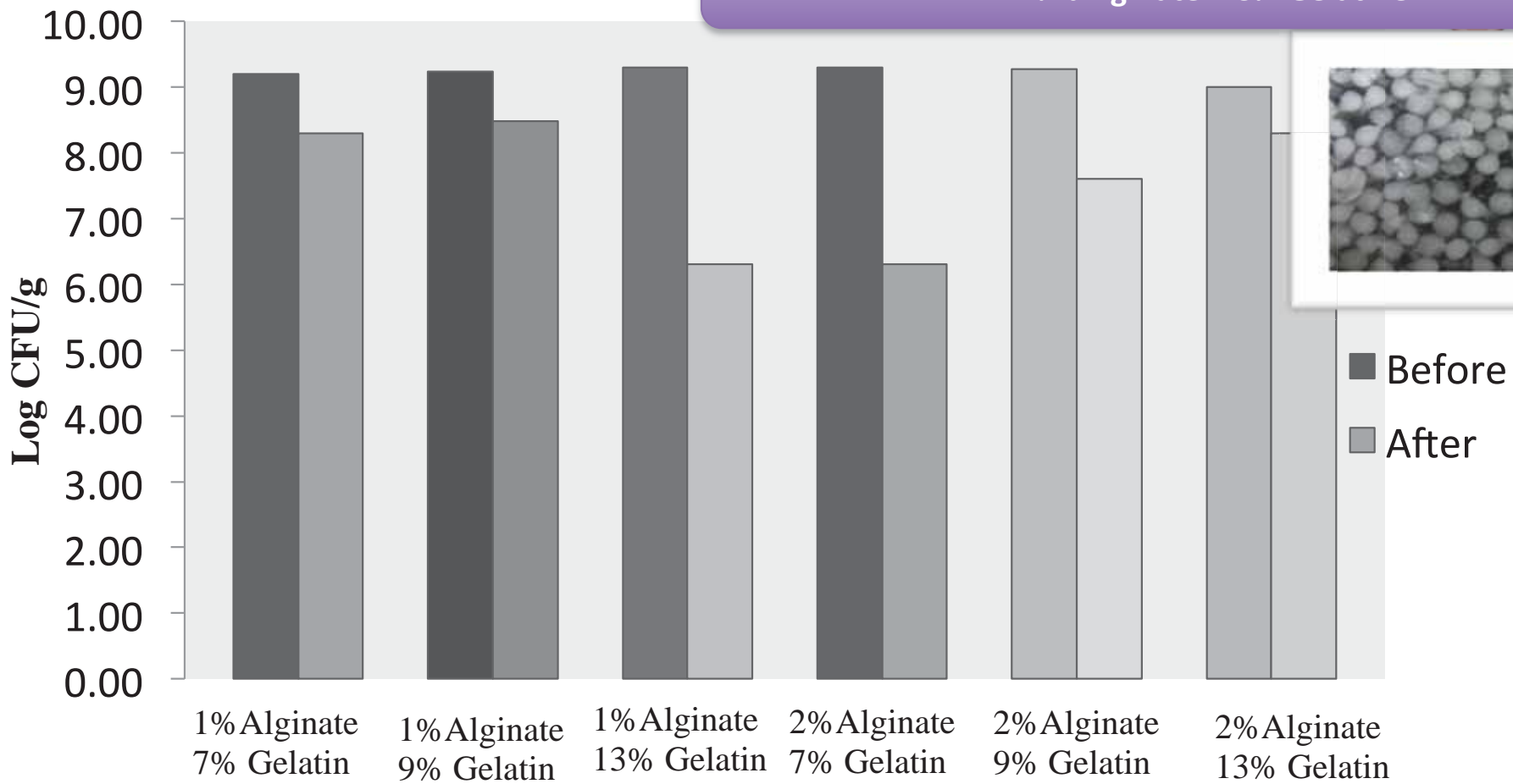


FRAP value (mg FeSO₄/ mL) of turmeric beverage, turmeric powder with probiotic and turmeric powder only in rat plasma after a single oral administration of the sample (250 mg/kg body weight).



Optimization of encapsulating material by checking the survival of the Probiotic before and after encapsulation: **For Fish Feed**

This condition was optimized for the encapsulation of probiotics.
2% Alginate: 13% Gelatine



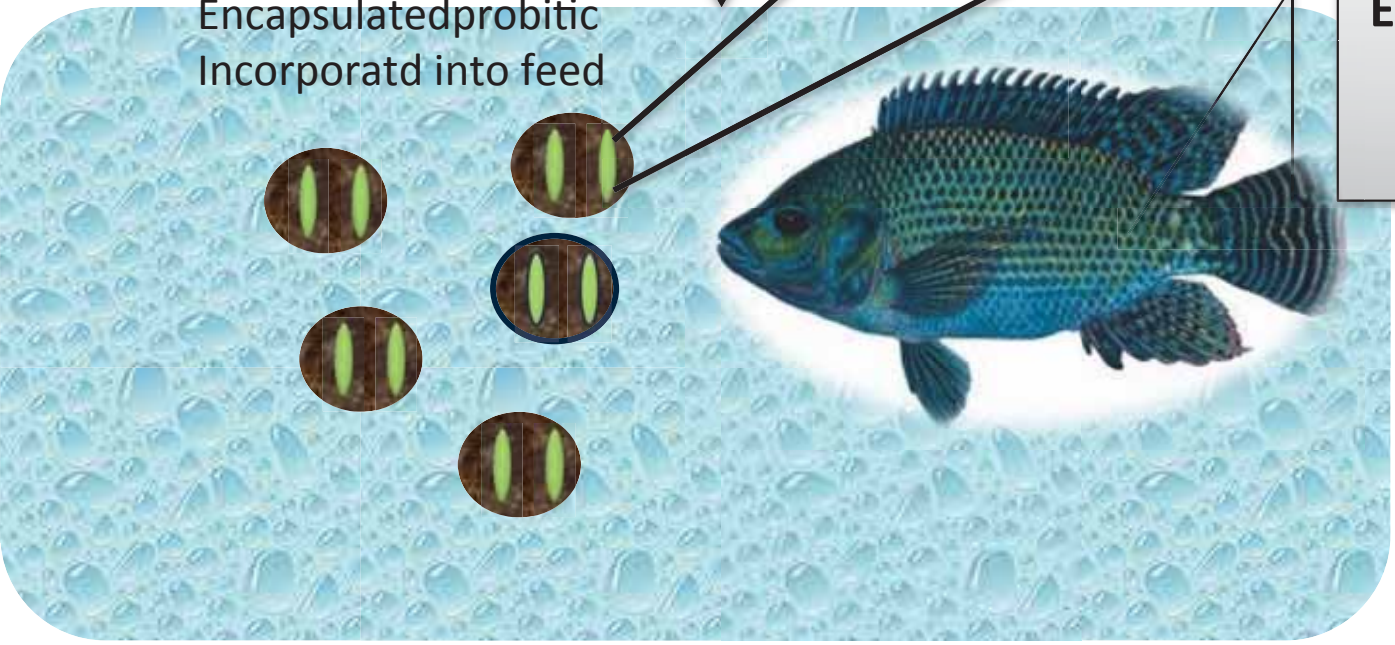
■ Before
■ After



Isolated probiotic

Encapsulating material
(e.g alginate and Gelatine)

bacteria + capsule = **bacteria**



Encapsulated probiotic
Incorporatd into feed

Encapsulated bacteria
intake by the fish at
proper condition.

Implications of Research in Food and Pharmaceuticals

- **Industrial Applications**
 - Harsher processing and storage conditions are tolerable for *Probiotics and other bioactive compounds*
 - Higher efficacy
 - Applicable in Food, Feed, Pharmaceutical, Cosmetic and biomedical applications.
 - Fast and economic
 - Use of Natural and biological materials
- **Health Applications**
 - Enhanced bioavailability
 - Targeted delivery
 - Pulsatile Delivery

Microbial Food Safety

Food Preservation

Inhibition Spoilage

Chemical

Acidification
Wateractivity
Preservatives

Physical

Freezing
Refrigeration

Inactivation Spoilage Pathogenic m/o

Pasteurization

Thermal

Heat
Dielectricheating
Ohmicheating
PEF

Nonthermal

Irradiation
UV light
High Pressure

Sterilization

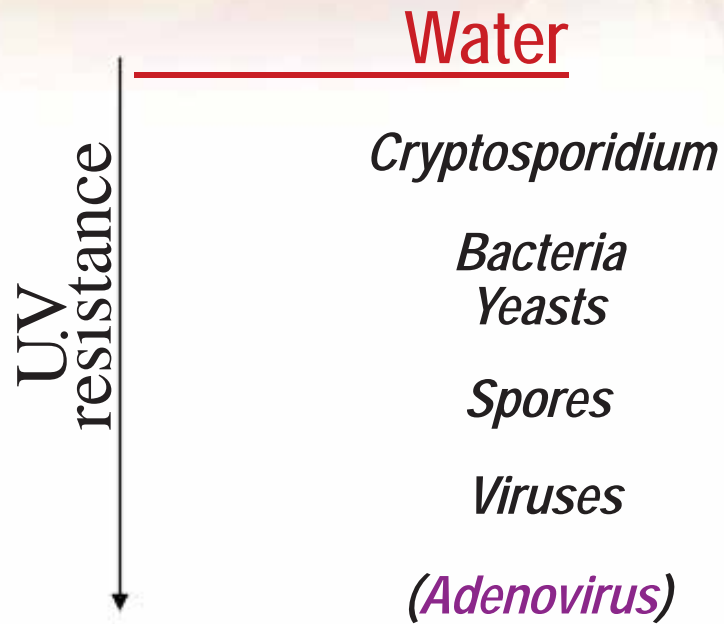
Thermal

Heat
High Pressure+heat
Dielectricheating

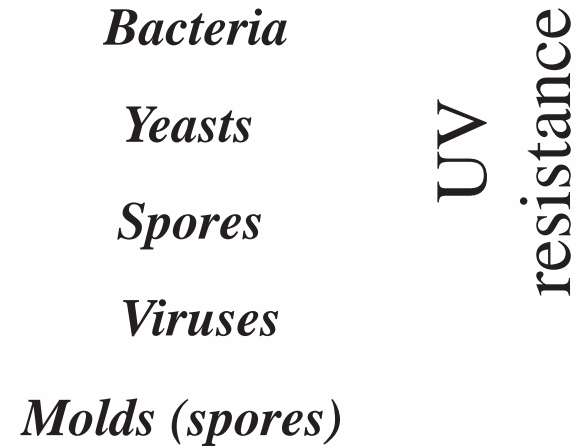
Non-thermal

Gamma
Irradiation

UV sensitivity



Liquid Foods



Depends on wavelength

Emission Spectrum

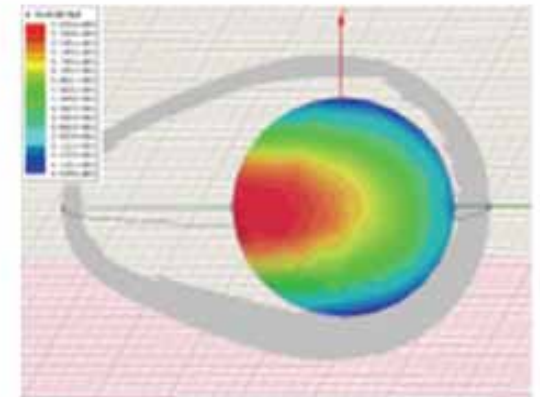


MICROWAVE heating

- MW energy is generated by special oscillator tubes magnetrons or klystrons
- MW energy is transmitted to an applicator or antenna through a waveguide or coaxial transmission line
- MW are guided primarily a radiation phenomenon
- MW are able to radiate into a space which could be the inside of the oven or cavity

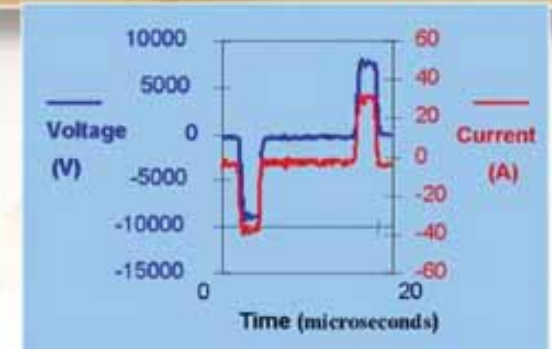
Advantageous MW Processes

- ✓ Pasteurizing or cooking high-viscosity, low-acid liquids (pH>4.6), liquids with particles
- ✓ Pasteurizing products with fouling problems
- ✓ Pasteurizing heat labile products
 - ✓ quality optimization
 - ✓ In-shell eggs
- ✓ MW high temperature - short time sterilization (HTST)



PULSED ELECTRIC FIELD Technology

High intensity (PEF) processing involves the application of pulses of high voltage (typically 20 - 80 kV/cm) to foods placed between 2 electrodes



PEF treatment is conducted at ambient, sub-ambient, or slightly above ambient temperature for less than 1 s

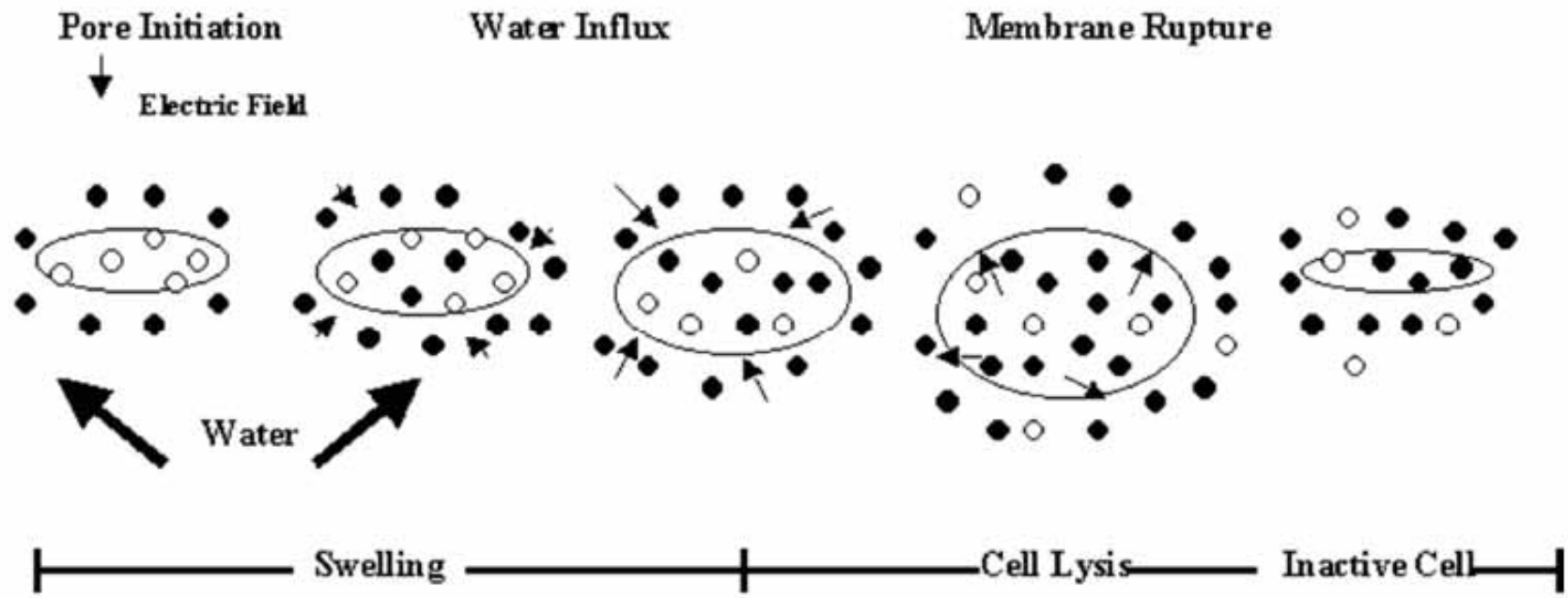
Energy loss due to heating of foods is minimized

For food quality attributes, PEF technology is considered superior to traditional heat treatment of foods

Avoids or greatly reduces the detrimental changes of the sensory and physical properties of foods

Microbial Inactivation Mechanism

- Electroporation



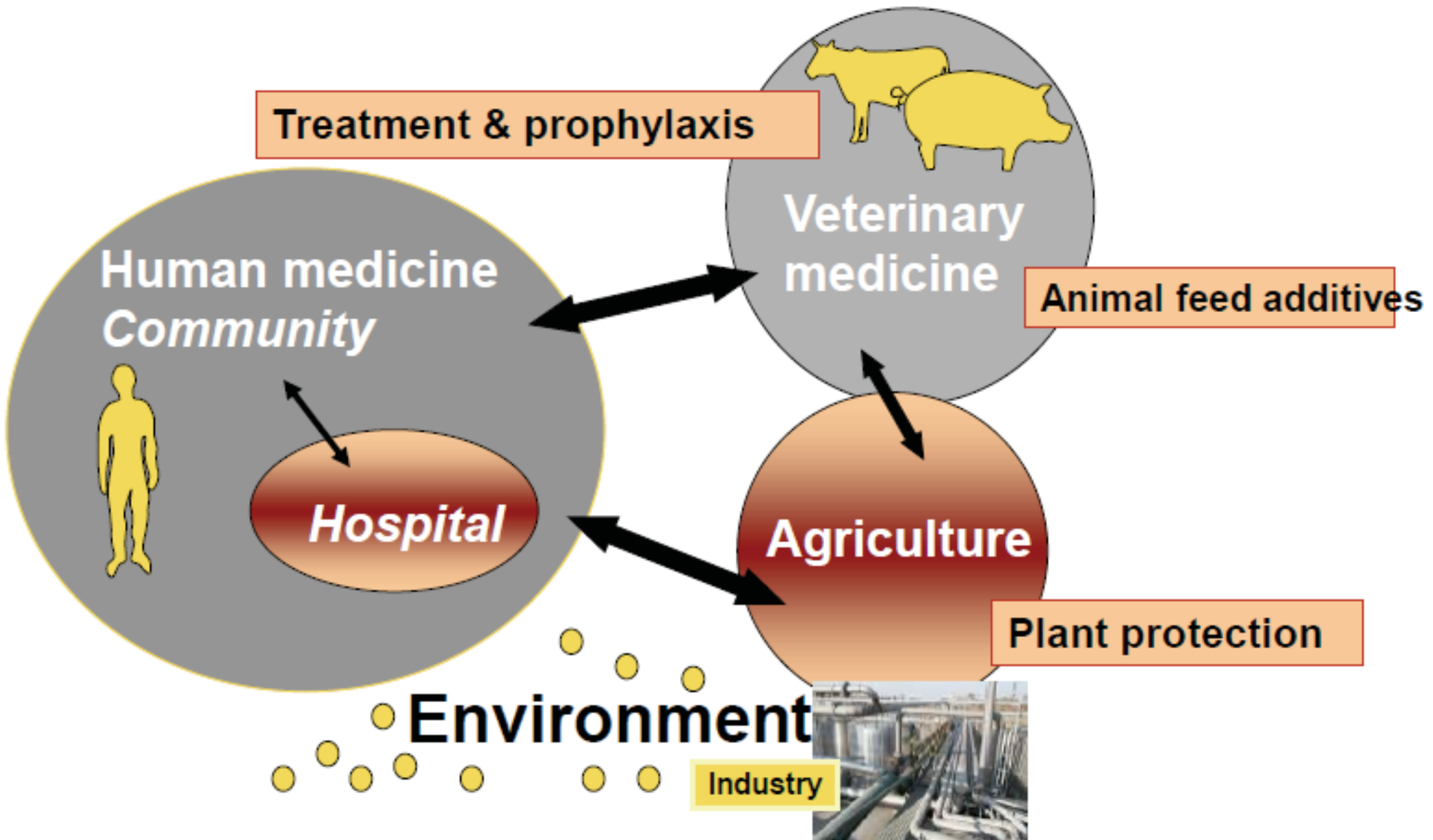
Vega-Mercado, 1996b



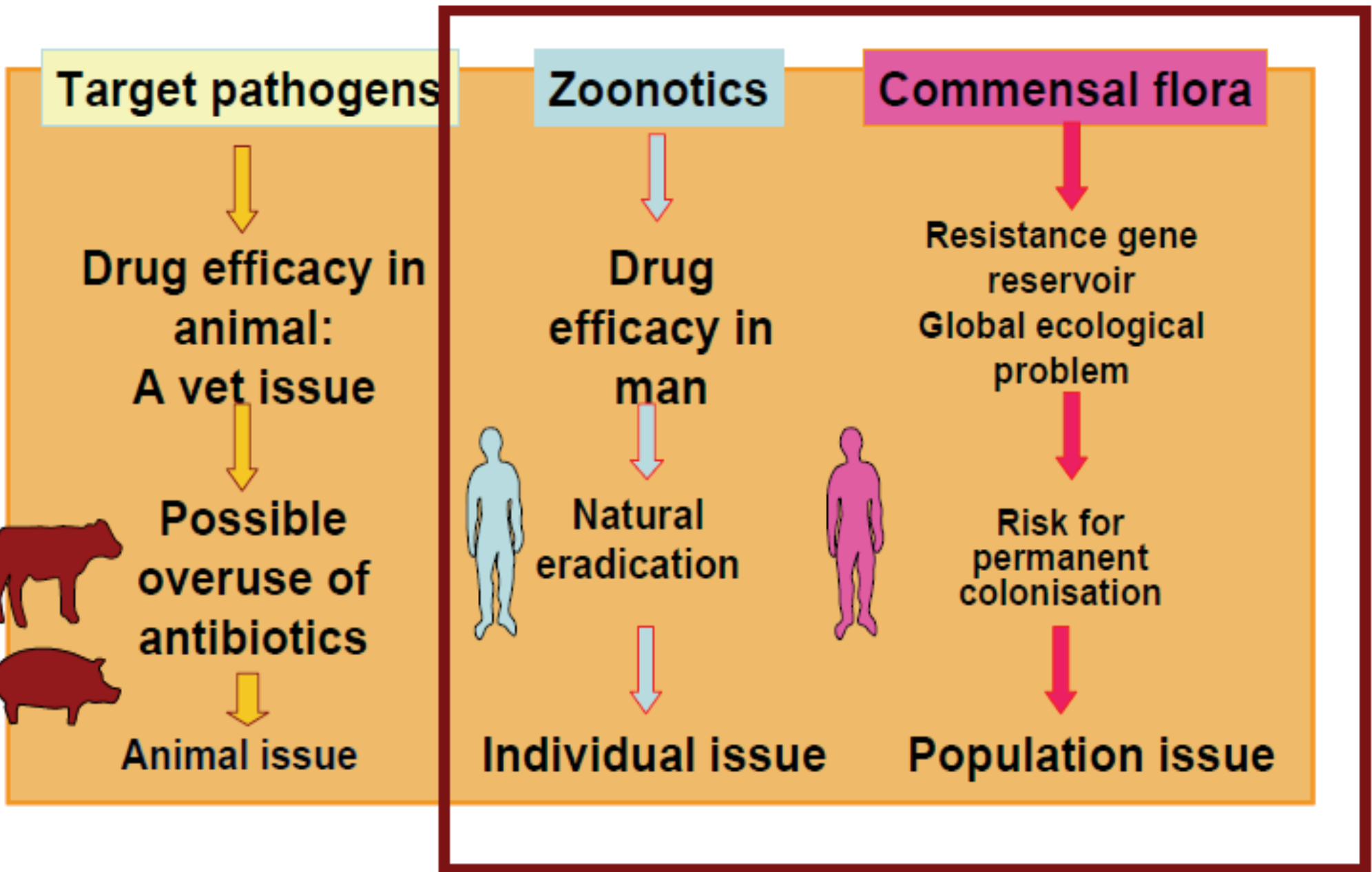
Antimicrobial Use in Livestock and Poultry Production



Co-relation



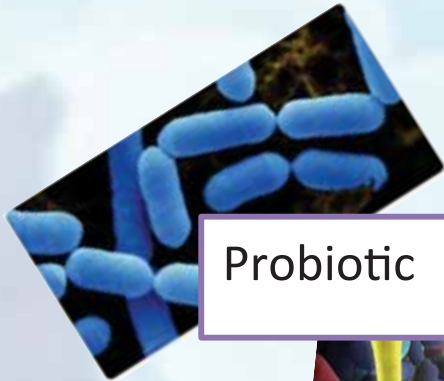
Major Issues and Concerns



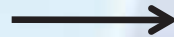
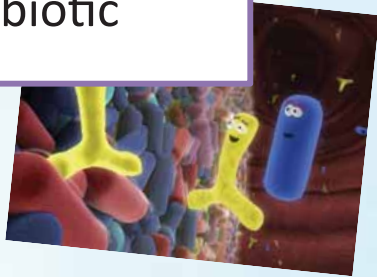
AN APPROACH to REDUCE USE OF
SYNTHETIC ANTIBIOTICS

***Lactobacillus plantarum and/ or
other Probiotics as Antibacterials***

ANTIMICROBIAL SUBSTANCES



Probiotic



Antimicrobial substances

Organic acid

Hydrogen peroxide

Carbon dioxide

Diacetyl

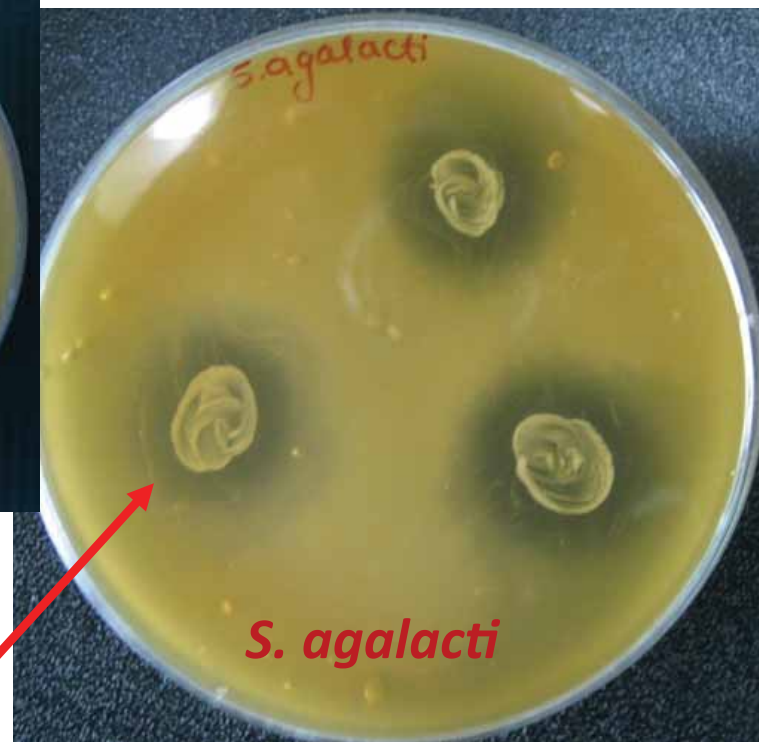
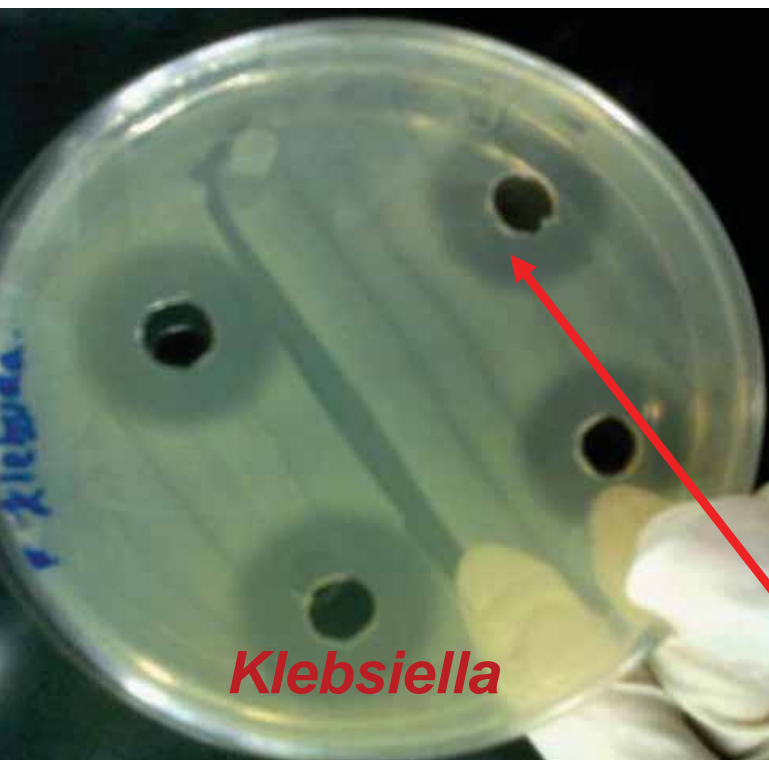
Bacteriocin



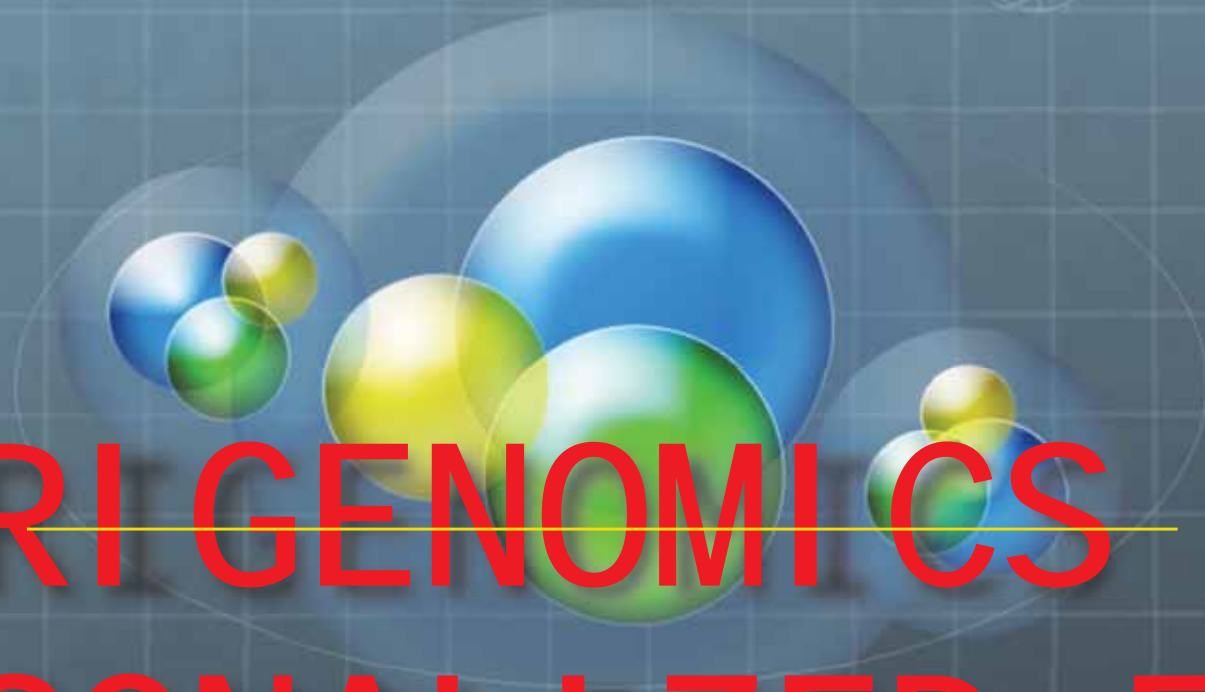
- Non toxic to human
- Do not alter the nutritional properties
- Effective at low concentration
- Active under refrigerated storage
- Use as food biopreservation

Antibacterial activity result of the LAB (Mixed Culture Activity)

Pathogenic bacteria species	Presence of Inhibition zone
<i>Escherichia coli</i>	Present
<i>Streptococcus agalactiae</i>	Present
<i>Salmonella, Staphylococcus</i>	Present
<i>Klebsiella pneumoniae</i>	Present



Inhibition Zone



NUTRIGENOMICS AND PERSONALIZED FOOD

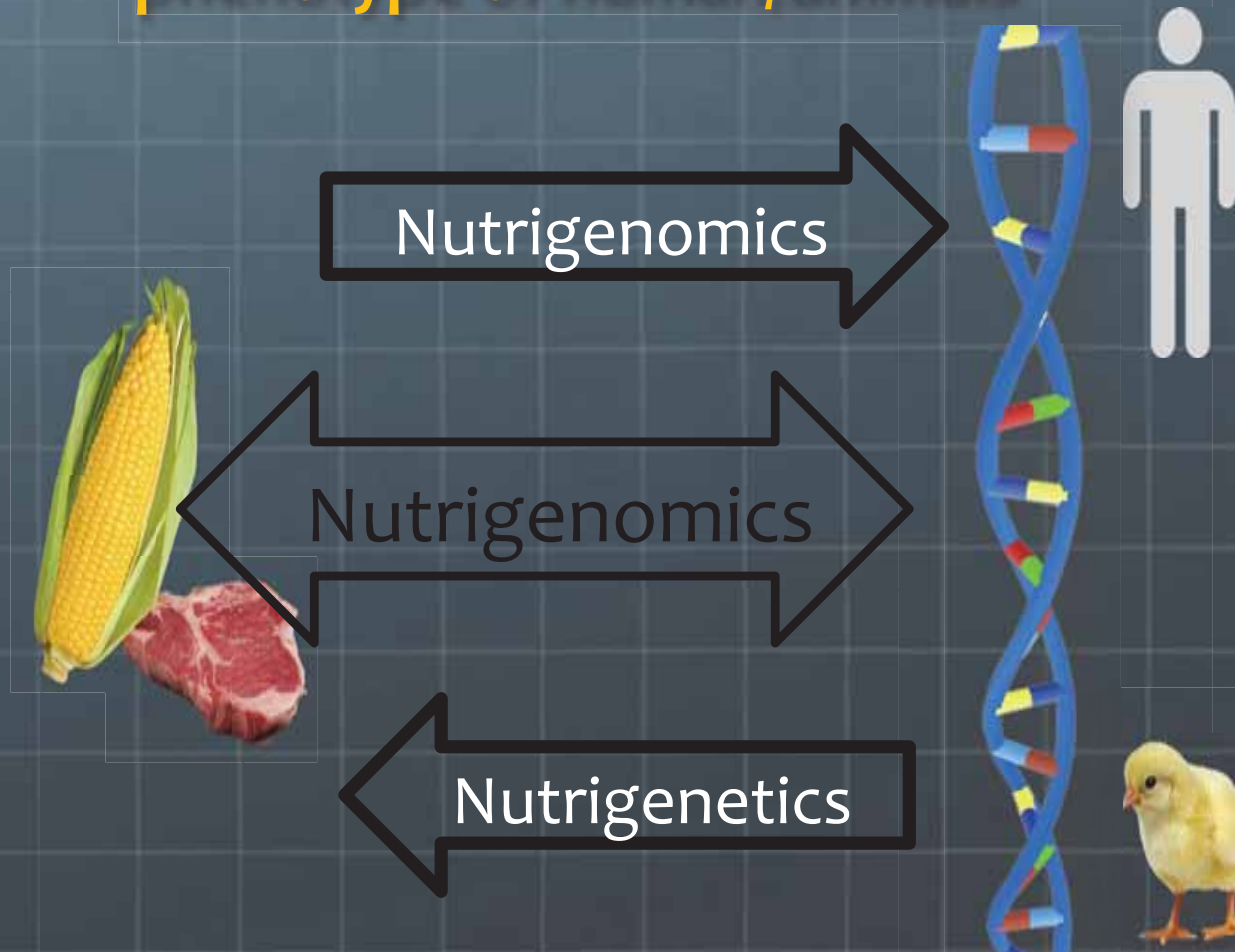




Nutrigenomics

🌐 Nutrient-genome interaction that effects the phenotype of human/animals

- Health



- Economic
- Growth, breeding
- Food quality
- Food safety



Nutrigenomics

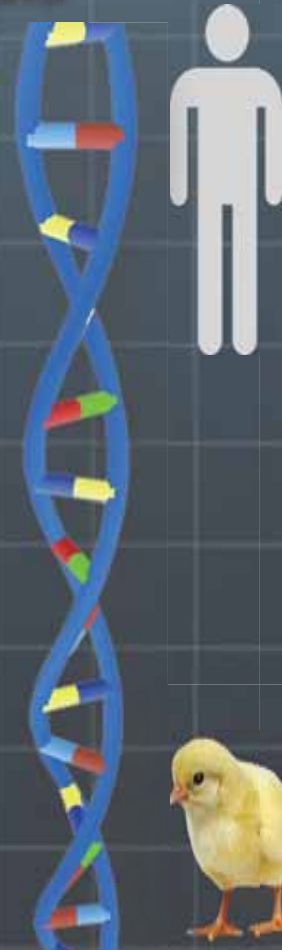
🌐 Nutrient-genome interaction that effects the phenotype of human/animals

- Health

Nutrigenomics

Nutritional genomics

Nutrigenetics



- Economic
- Growth, breeding
- Food quality
- Food safety

'omic'

technologies



AIT TECHNOLOGY EVENT

Nutrigenomics

Nutrients



DNA

RNA

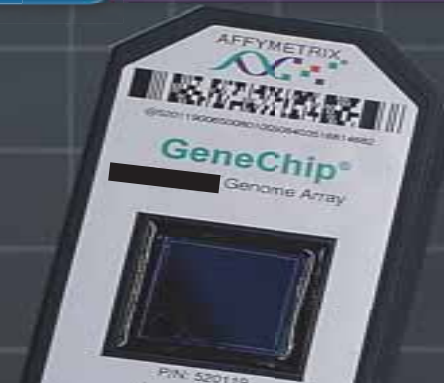
Protein

Metabolite

Transcriptomics

Proteomics

Metabolomics

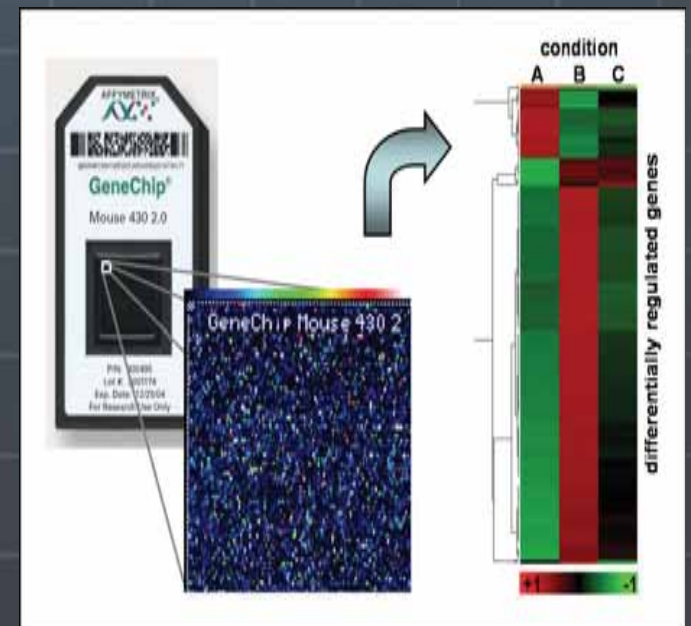


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Transcriptomics: DNA microarray

- A microarray is equivalent to thousands of PCR reactions
- Can detect thousands of genes at one time
- Different types of microarrays
- cDNA microarray

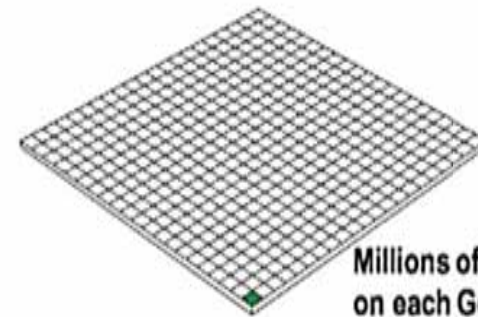
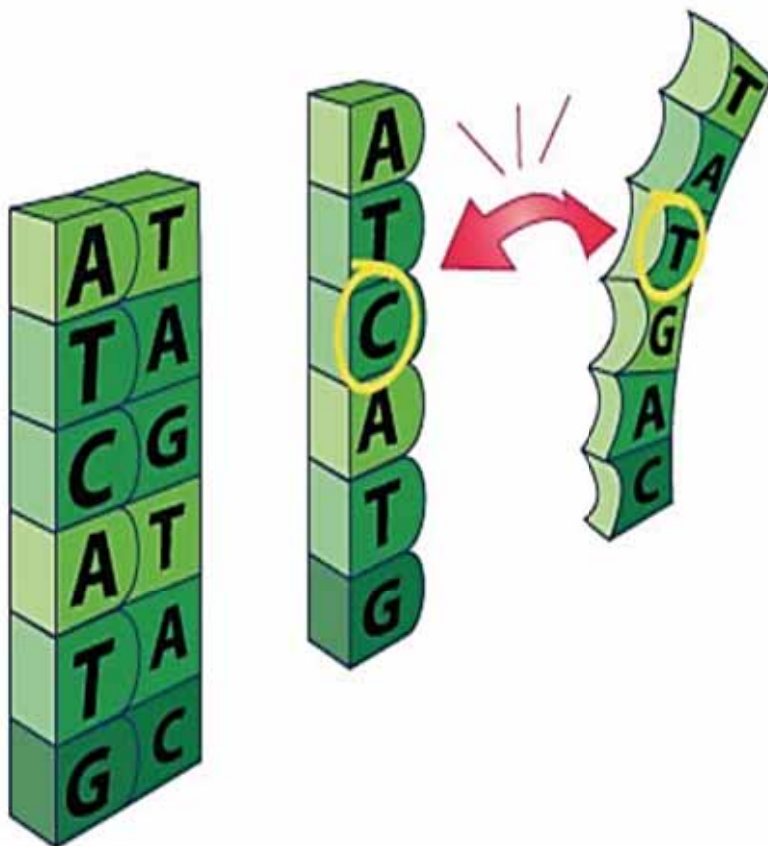




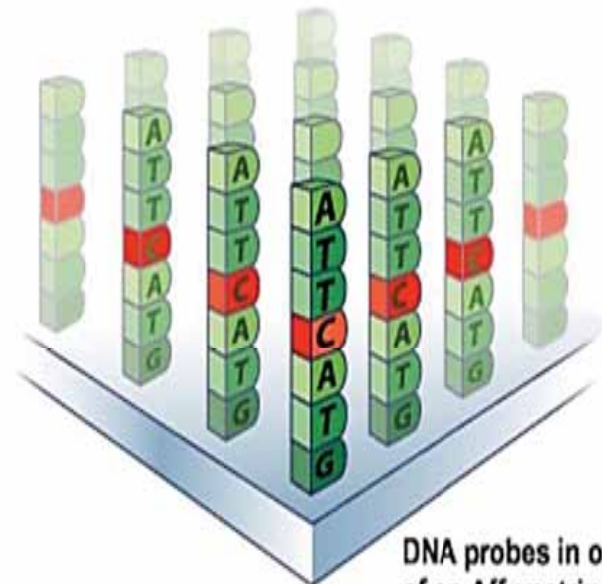
Affymetrix DNA microarray

Nucleotide matching concept

Setting probes into array



Millions of features possible on each GeneChip® array

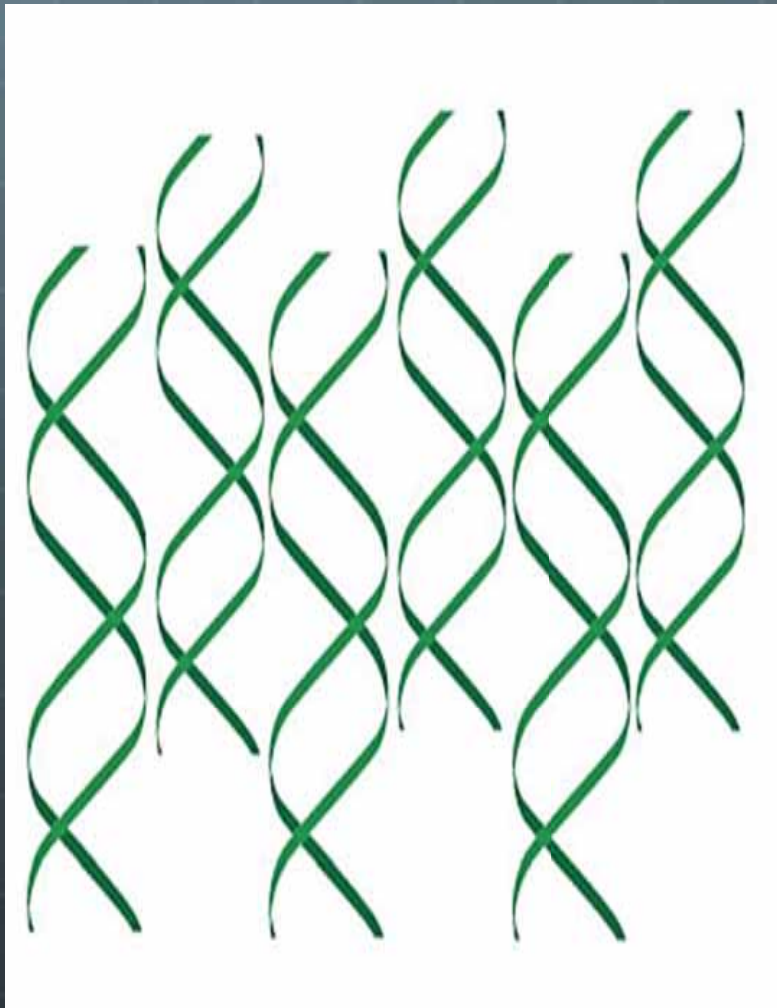


DNA probes in one corner of an Affymetrix array

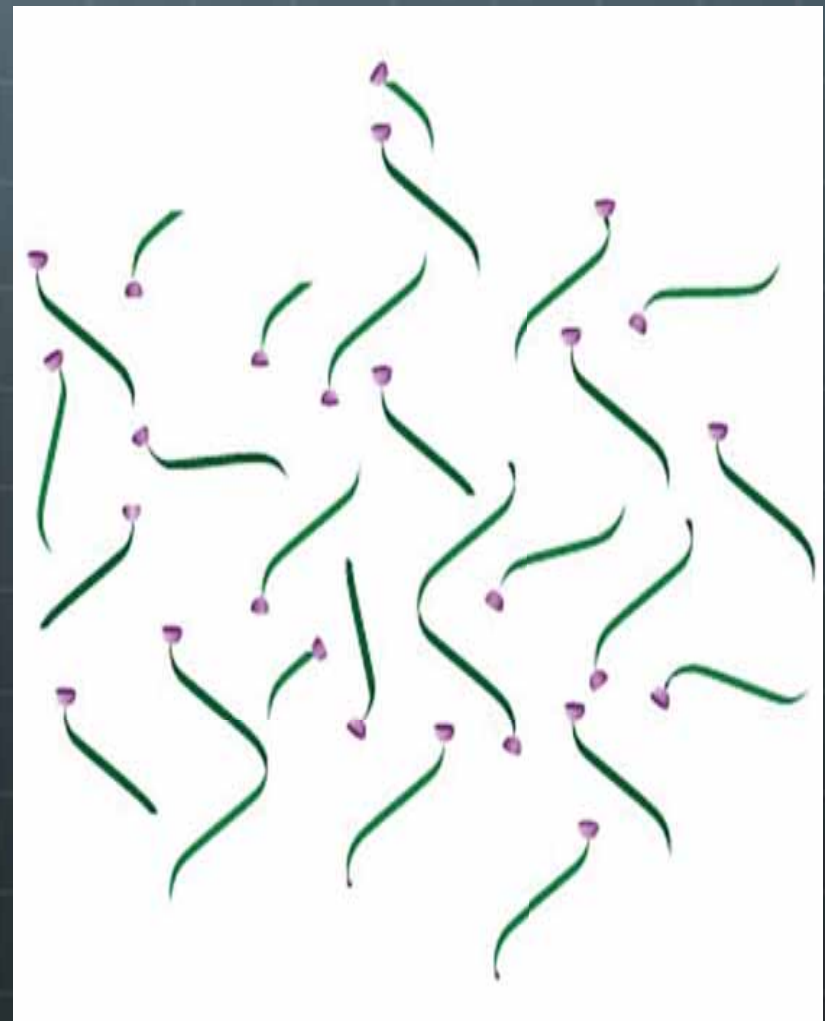


Affymetrix DNA microarray

Sample RNA to
cDNA



Chopped and labelled
(biotin)





Application of Transcriptomics

Beef (red meat) & colon cancer risks

Red meat – high heme concentration

• Tested on rats using cDNA microarray

• Result


• Dietary heme increased cytotoxicity of fecal water in colon

• Elevated epithelial proliferation

• Carcinogenic


• Moreover, calcium reduced carcinogenic effects



 **Nutri genomics: Emerging tool in nutritional research**



 **Human – health, personalized diets**

 **Livestock – Growth, breeding, economic, food quality and safety**

Foods to Drugs....

