

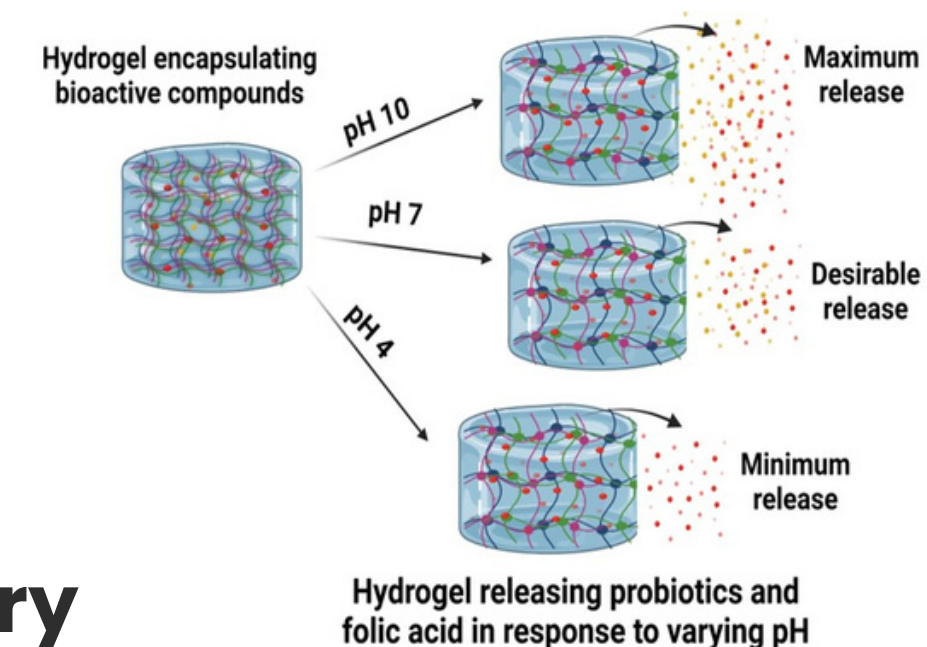
Technology Match Maker | Sustainable Ingredients for Functional Foods & Additives | Oct 2023

Novel Functional Food Ingredients With Bioderived Co-encapsulation Of Probiotics and Nutrients

Lead Scientist: Dr Anirban Roy Choudhury

Organization: CSIR-IMTECH

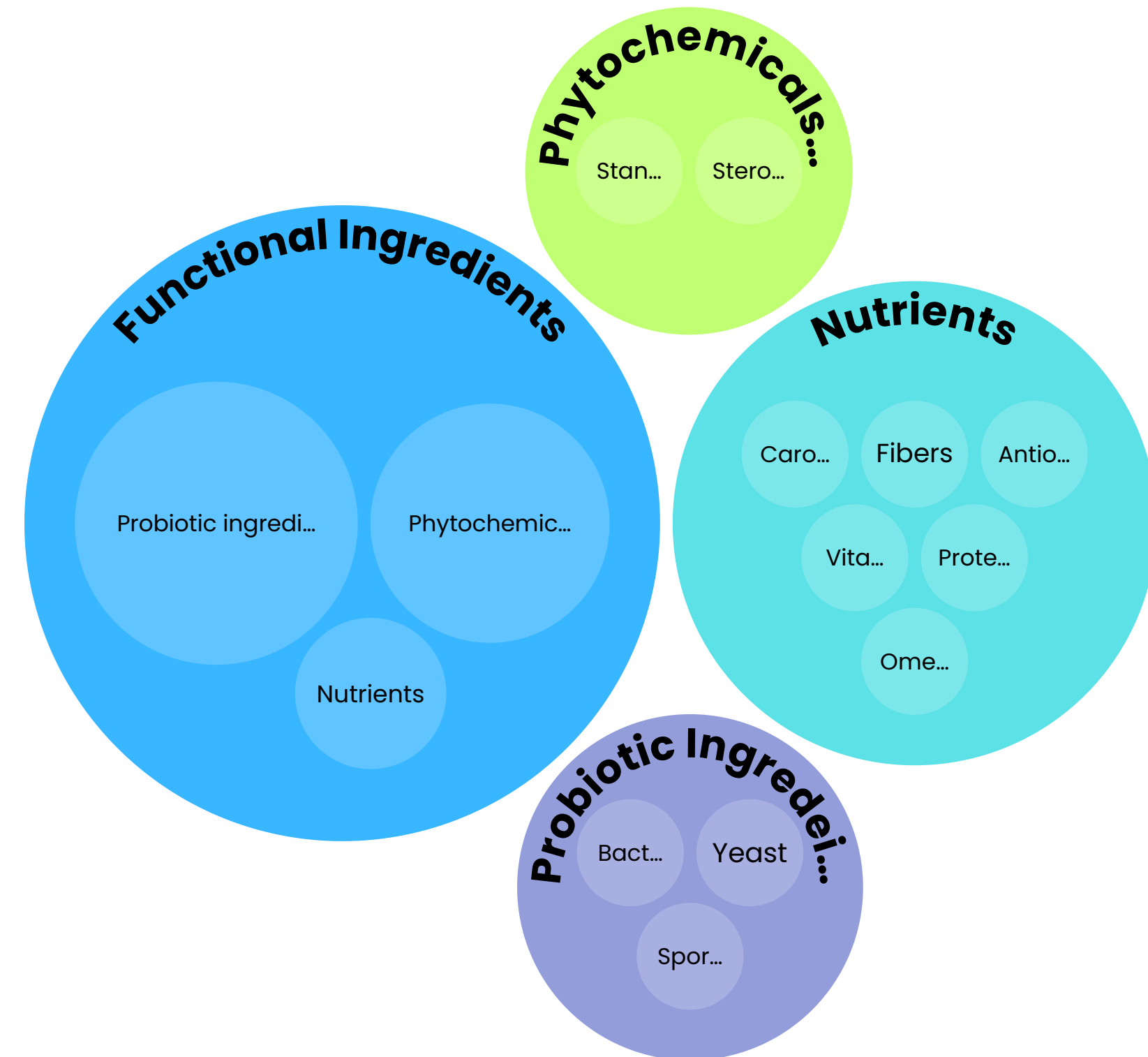
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Functional Food Ingredients

- Functional ingredients are bioactive molecules that provide additional or enhanced benefits over basic nutrition.
- Various types of functional ingredients are used in making functional foods & beverages.
- Efficacy of functional foods depend on bioavailability of the functional ingredients.
- Increasing bioavailability can reduce the quantity of functional Ingredient needed, and hence increasing affordability of the functional food.
- Bioavailability can be increased by techniques such as encapsulation techniques, liposomal delivery etc.



Market Opportunity

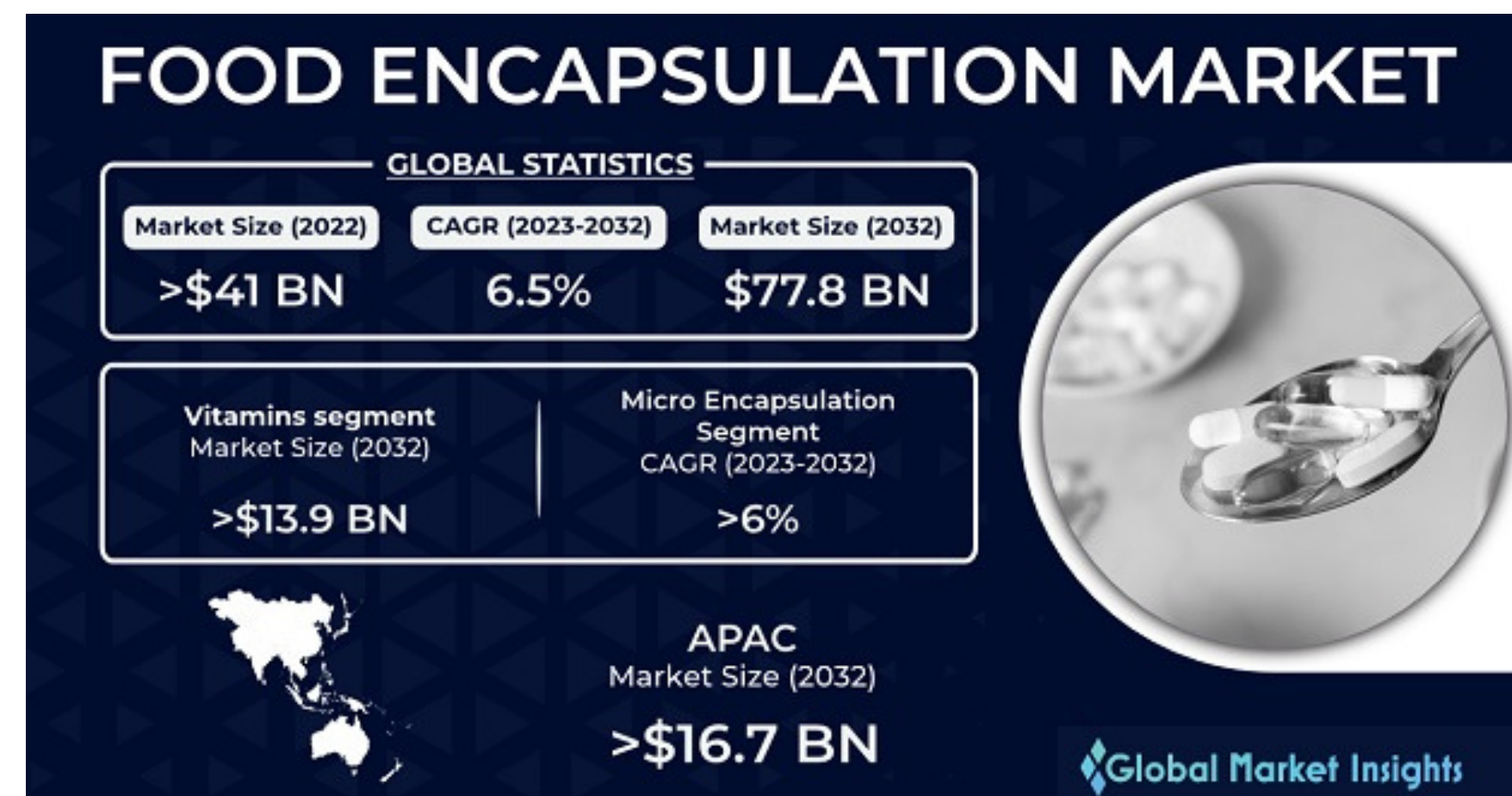
Global food encapsulation market was valued at USD 41 B in 2022 and is expected to grow at CAGR 6.5% reaching USD 77.8 B in 2032.

Key Market Drivers are:

- Increasing consumer demand for functional foods.
- Rising demand for clean label products.
- Growing health awareness.

Market leaders: Cargil, IFF, DSM, BASF, Symrise, Ingredion

Challenges: Higher investment and production cost.



Opportunity for developing newer functional food ingredients with lower cost, multiple benefits and effective delivery systems.

Who Should Be Interested?

Who?	Why?
Functional foods companies with focus on health and nutrition	<ul style="list-style-type: none">• Simultaneous delivery of multiple functional ingredients.• Developing novel functional food ingredients.• Enhancing bioavailability of probiotics.
Food & beverages companies	<ul style="list-style-type: none">• Masking undesirable smell/ taste etc.• Incorporating unstable ingredients in products.
Nutraceutical companies	<ul style="list-style-type: none">• Novel targeted delivery system.• Biocompatible & biodegradable encapsulation matrix.
Drug delivery and pharmaceutical companies	<ul style="list-style-type: none">• Platform for developing novel targeted delivery systems.• Biocompatible & Biodegradable encapsulation matrix

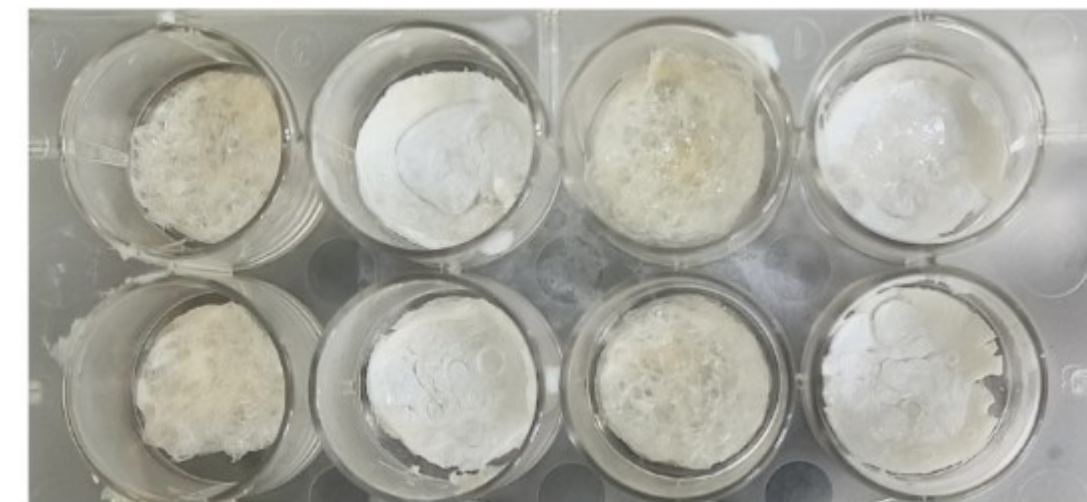
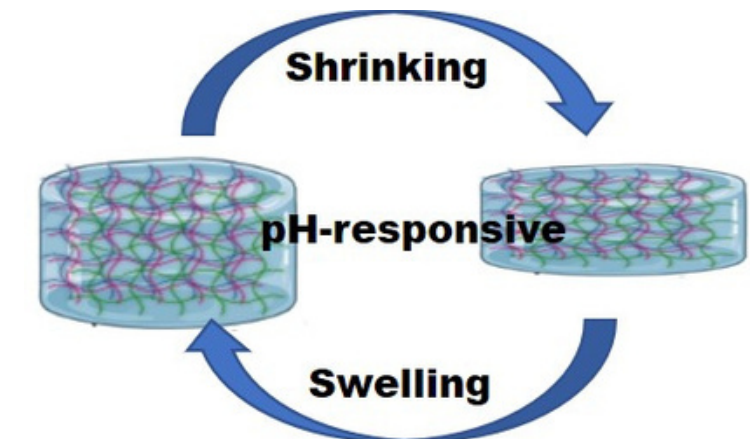
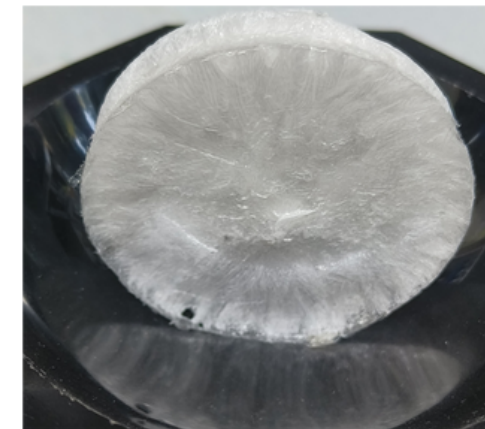
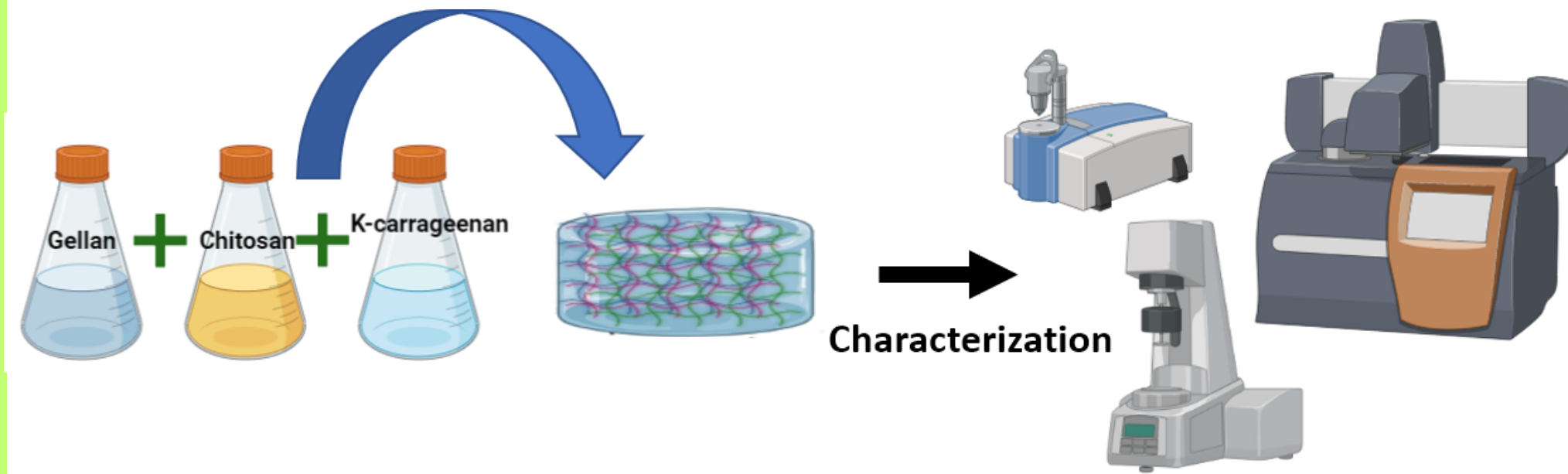
About the Technology

Process features:

- **Unique co-encapsulation matrix:**
 - **Self-assembling, two or more natural polysaccharides** => biocompatible, biodegradable, sustainable technology.
 - **USFDA approved food additives** => safe, non-immunogenic, non-toxic.
 - **Physical crosslinking** by simple mixing
 - **Can be 3D printed** => for controlled pore size and release profile of encapsulant.

Product features:

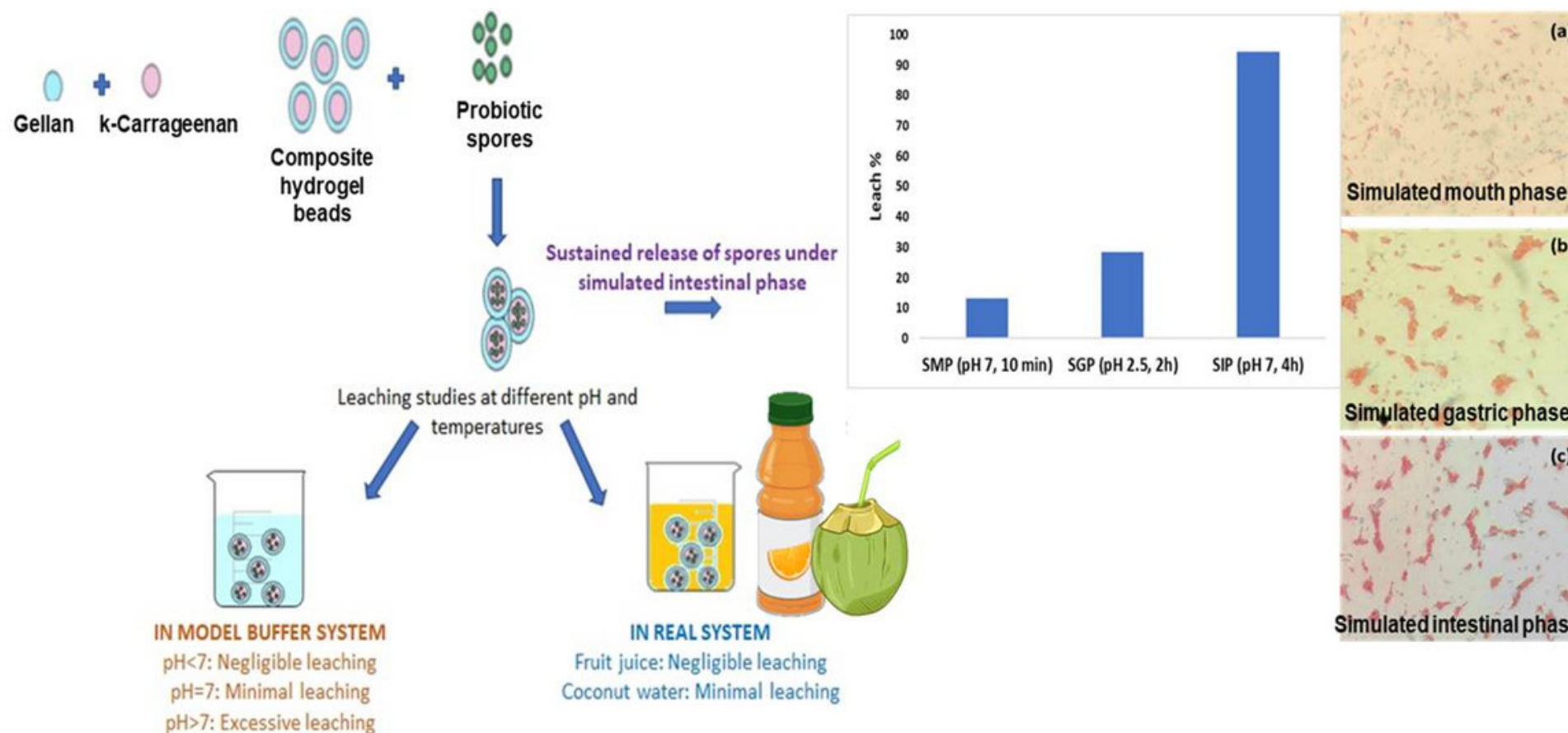
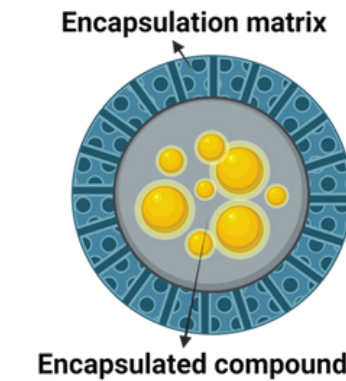
- **Final form of product is dried powder, taking colour of the natural polysaccharides used.**
 - **pH responsive encapsulant** => sustained, site-specific release for targeted delivery.
 - **Stable in gastric pH conditions** => low leaching and increased bioavailability of encapsulated ingredients in the gut.
 - **High mechanical strength** => maintains bioactivity of encapsulated ingredients.



Fortified Beverages ~ A Case Study

A novel co-encapsulated functional food ingredient was developed for fortification of commercially available fruit juices and coconut water with probiotics.

- Co-encapsulation Matrix => Natural polysaccharides gellan gum and κ-carrageenan.
- Encapsulated material => Spores of *Bacillus* as probiotics.



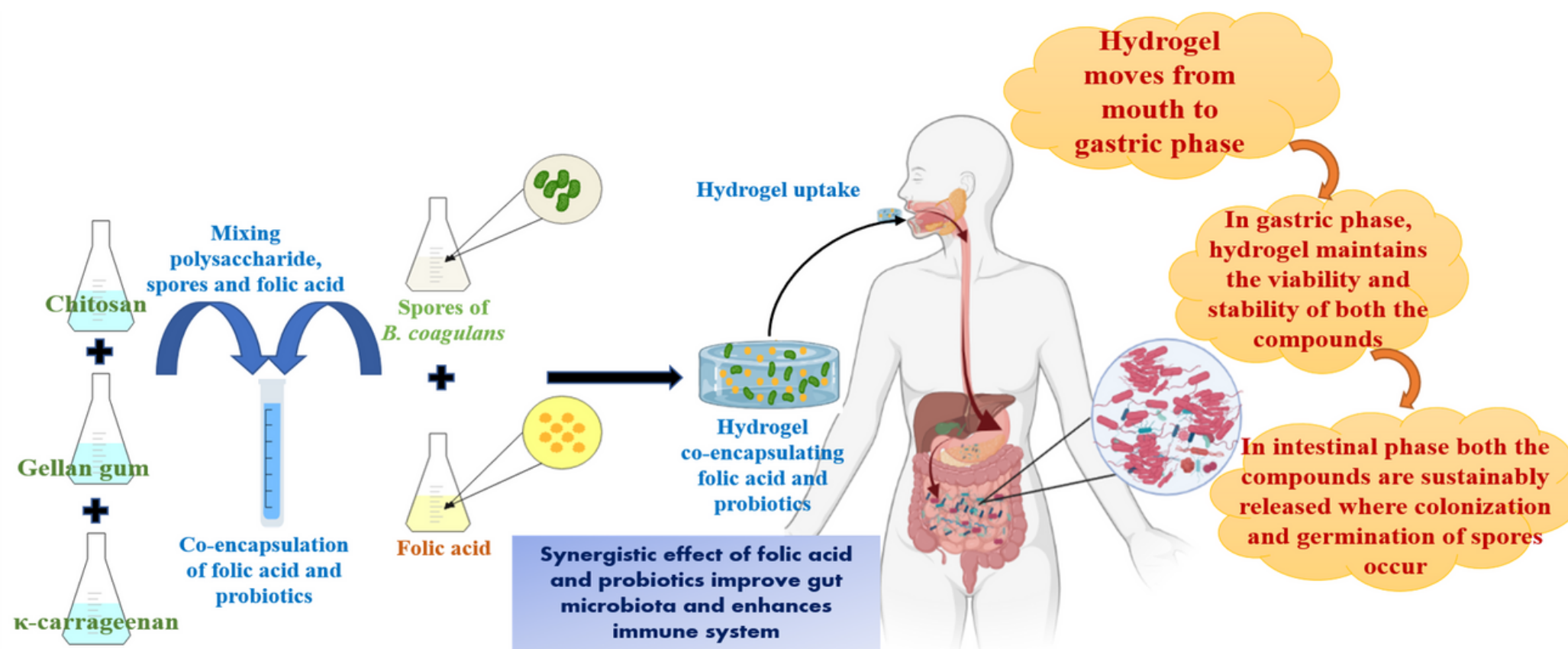
- **Stable encapsulated functional food ingredient:** Fortification with bacterial spores loaded encapsulation did not adversely affect the product stability or shelf-life.
- **Product shelf-life:** Accelerated spoilage studies for the beverages loaded with encapsulated spores suggested that, both fortified fruit juice and coconut water can be stored up to 30 days in ambient conditions.

Tri-composite system ~ A Case Study

A novel tri-composite functional food ingredient for co-encapsulation of probiotics and vitamins.

- Co-encapsulation Matrix => Natural polysaccharides Chitosan, gellan gum and κ-carrageenan.
- Encapsulated materials => Spores of *Bacillus* as probiotics and Vitamin B9 (folate/folic acid).

- **Stable encapsulated functional food ingredient** - Elastic in nature, very high swelling capacity of 3000% to 7500%. Mechanical strength measured using rheometer showed significant advantage over individual polymers such as gellan, chitosan and κ-carrageenan.
- **High encapsulation efficiency** of 88-93% for probiotic spores and 50-70% for folic acid.
- **Loading capacity** of 5 mg/ml folic acid and 10^8 cfu/ml probiotics.
- **Maintained viability and stability**, In-vitro digestion studies suggested controlled delivery of compounds in the gut along with conversion of probiotic spores to vegetative cells.



Current Status

Technology Status:

- Demonstrated proof-of-concept at lab-scale using in-vitro simulations for targeted delivery and intestinal availability of functional food ingredient.
- 3D printing trials and testing ongoing.
- In-vivo studies for tri-composite system ongoing

IP Status: Patent Application filing in progress.

Publications:

- Richa, Anirban Roy Choudhury, Encapsulated probiotic spores as a fortification strategy for development of novel functional beverages, Innovative Food Science & Emerging Technologies, Volume 80, Aug 2022, Pages 103-104.
- Nandita Srivastava, Richa, Anirban Roy Choudhury, Enhanced encapsulation efficiency and controlled release of co-encapsulated Bacillus coagulans spores and vitamin B9 in gellan/ κ -carrageenan/ chitosan tri-composite hydrogel, International Journal of Biological Macromolecules, Volume 223, 2023, Pages 231-240.

Team & Organisation



Lead Scientist:

Dr Anirban Roy Choudhury

- **Senior Principal Scientist**, CSIR -IMTECH, Chandigarh.
- **Expertise:** Bioprocess Development and Scale up, Fermentative production of polysaccharides, Polysaccharide based biomaterials.
- More than 20 years of experience in the industry and academia.
- **Successfully delivered many industry sponsored projects.**

CSIR-Institute of Microbial Technology (IMTech) national laboratory is the forerunner in the domain of microbial biotechnology research and development.

Key assets and strengths of the team:

- 35+ publications in bioprocess development and microbial technology.
- **Team Strength:** 5
- **Well equipped labs and analytical facilities:** Lab-to-pilot-scale fermenters of capacities varying from 2 to 1,500 litres for continuous and batch fermentation, high-capacity homogenizers, centrifugal separators, ultrafiltration, rotary vacuum filter, spray drier; Large-scale downstream processing equipments.
- **Industry projects/ Tech transfer:** Panacea Biotech, IFB Agro, ExcelEx Biopolymers, Dhampur Sugar Mills



Next Steps

- Team has developed the background science and demonstrated proof-of-concept at lab-scale using in-vitro simulations.
 - Trials and testing of 3D printed matrix product ongoing.
 - Further in-vivo studies ongoing.
- The team has expertise to modify and get desired functional food ingredients.
- Next phase will be to work closely with industry partners to:
 - Develop and optimise product as per specification.
 - Establish stability and shelf-life of fortified products.

Seeking:

- **Industrial partners interested in technology licensing.**
- **Industrial partners interested in sponsoring further technology advancement and scale up.**
- **Industrial partners interested in raising 3rd party funds for a collaborative project.**
- **Industry interested in tapping scientist capabilities as an expert/consultant.**

For More Information Contact:

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References

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- Slide 2 - <https://inewtrition.com/delivery-system-functional-foods/>
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- Slide 6 - Richa & Anirban Roy Choudhury, (2022) Innovative Food Science & Emerging Technologies.
- Slide 7 - Srivastava, N., Richa & Roy Choudhury, A. (2023), International Journal of Biological Macromolecules.