

Match Maker/ Sustainable Ingredients/ 3 Feb 2023

Technological platform for encapsulation of nutraceuticals as functional foods

Lead Inventor: Dr Anirban Roy Choudhury

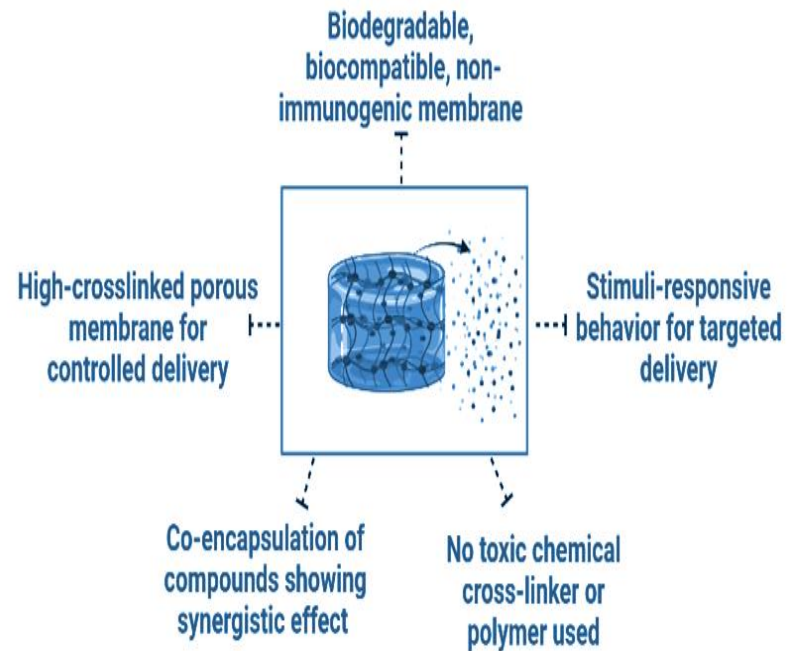
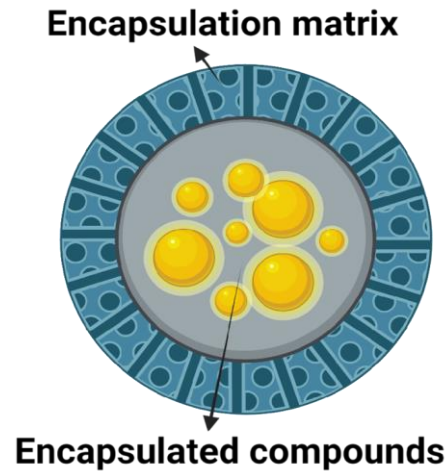
Organization: CSIR- Institute of Microbial Technology, Chandigarh

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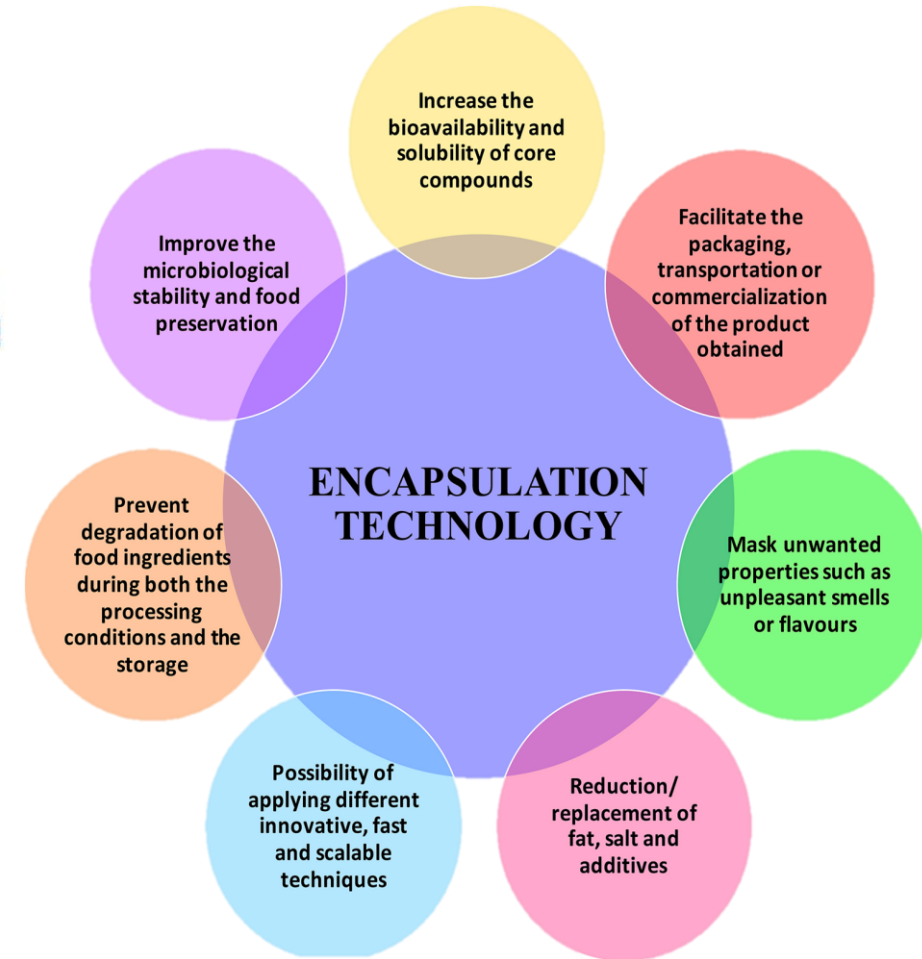
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Importance of encapsulation matrix



Properties of our system addressing the bottlenecks



Disadvantages

- Use of toxic chemical agents
- Time consuming method
- High energy consumption
- Low encapsulation and loading efficiency
- Non-specific delivery
- Synthetic material may have allergic response

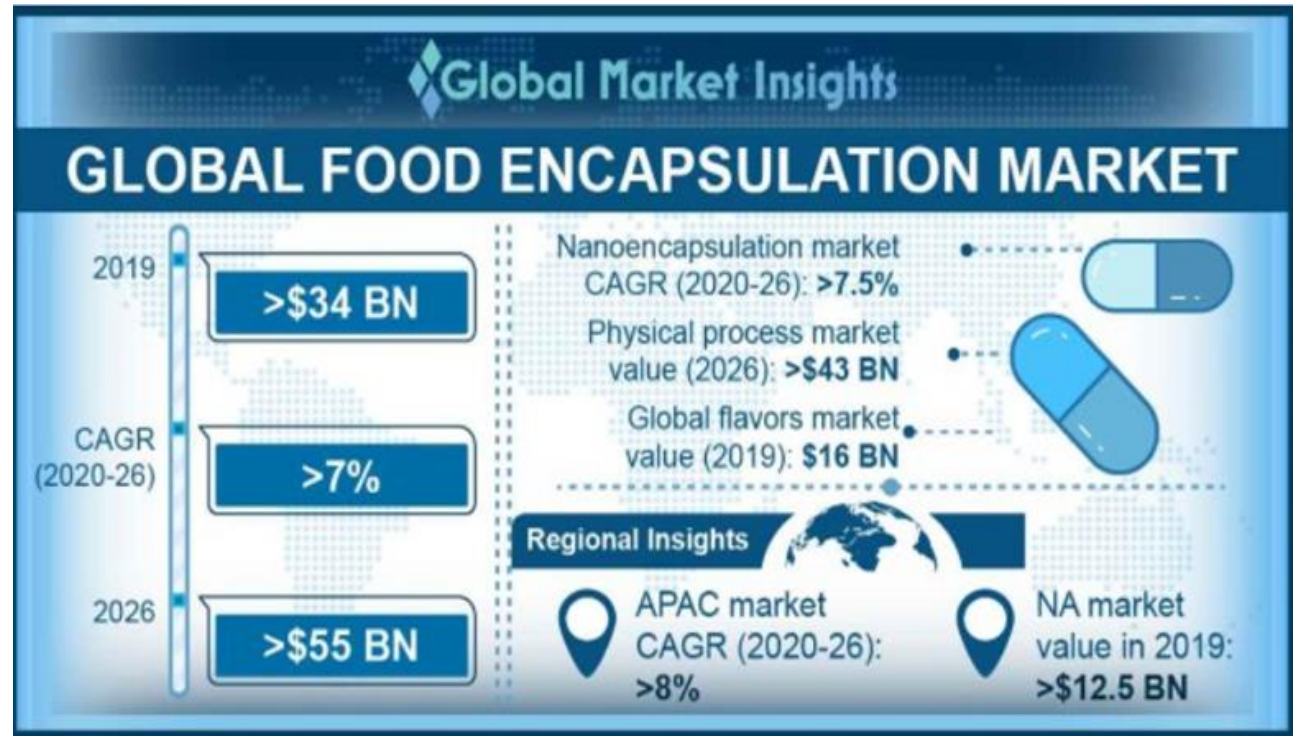
Drawbacks associated with other existing systems

The Opportunity

The food encapsulation market exceeded USD 34 billion, globally in 2019 and is estimated to achieve over 7% CAGR between 2020-2026
(Source: GM Insights)

Factors driving the growth for food encapsulation:

- Improved shelf-life of end-product
- Reduced nutrient loss
- Improved heat and oxidative resistance
- Targeted delivery



- **Major global players:** Cargill, DSM, IF&F, Givaudan, Symrise AG, Friemich, Friesl and Campina, Legris Industries Group, Kerry Group and Ingredion.

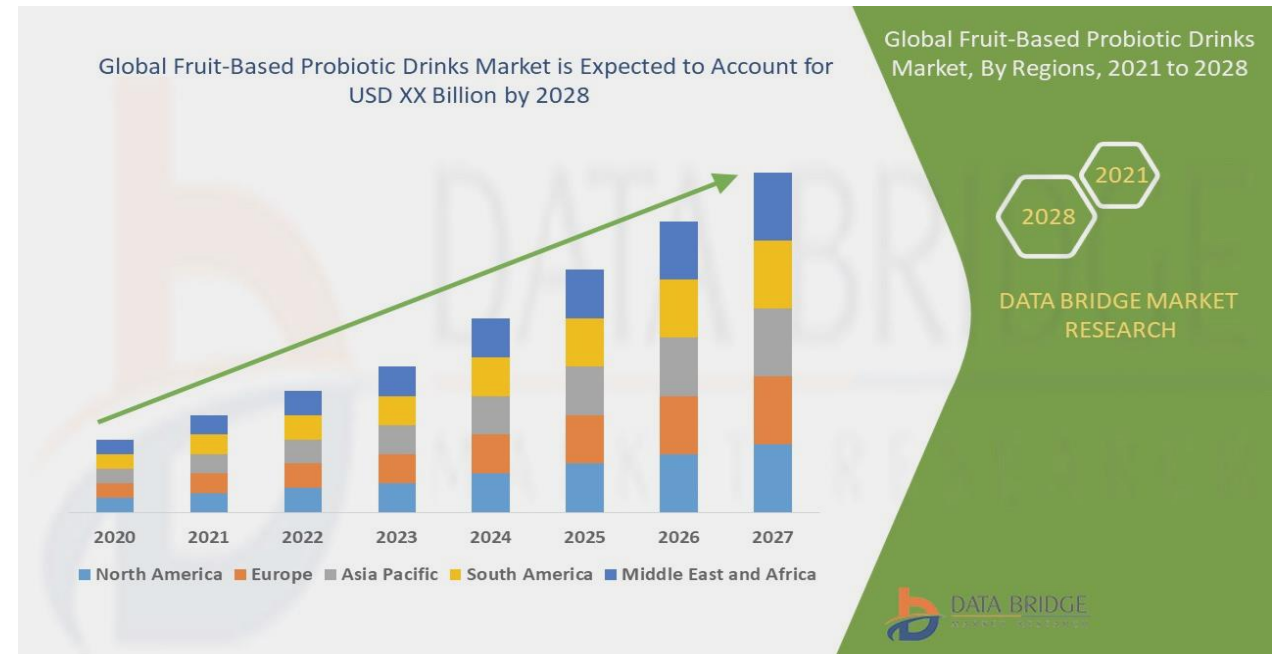
The Opportunity

The global probiotic drink market size was valued at USD 13.65 billion in 2019 and is expected to expand at a compound annual growth rate (CAGR) of 6.1% from 2020 to 2027 (Source: Grandview Research)

Fruit-based probiotic drinks market is expected to grow at a growth rate of 8.00% in the forecast period 2021 to 2028 (Source: Data bridge Market research).

Factors driving the growth for Probiotics:

- Digestive health, weight loss
- immune function
- improves bowel movement
- Nutrient absorption



Major global players: Yakult Honsha Co, Ltd, Danone S.A, GCMFM (Amul), PepsiCo, NextFoods, Harmless Harvest, Bio-K Plus International Inc, Fonterra Co-operative Group, Lifeway Foods, Nestle SA, Chobani, LLC.

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The Opportunity - *Fruit juices with probiotic properties minus the need for a cold supply chain.*

Converting your favourite fruit juice/coconut water into a probiotic drink!



Fruit juice / coconut water fortified with stable formulation of probiotics.



Drawbacks currently available products

- Requires refrigeration
- Shelf life 7-10 days after opening

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Who should be interested and why?



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Who?

Why?

Nutraceutical companies looking for biocompatible and biodegradable platform for encapsulation of nutraceuticals (matrix/beads)

Masking of undesirable color/flavor/taste, preservation of unstable constituents, and site-specific release of encapsulated ingredients at a controlled time and rate

Industries interested in developing new combination of encapsulation matrix along with supplying multiple nutraceutical

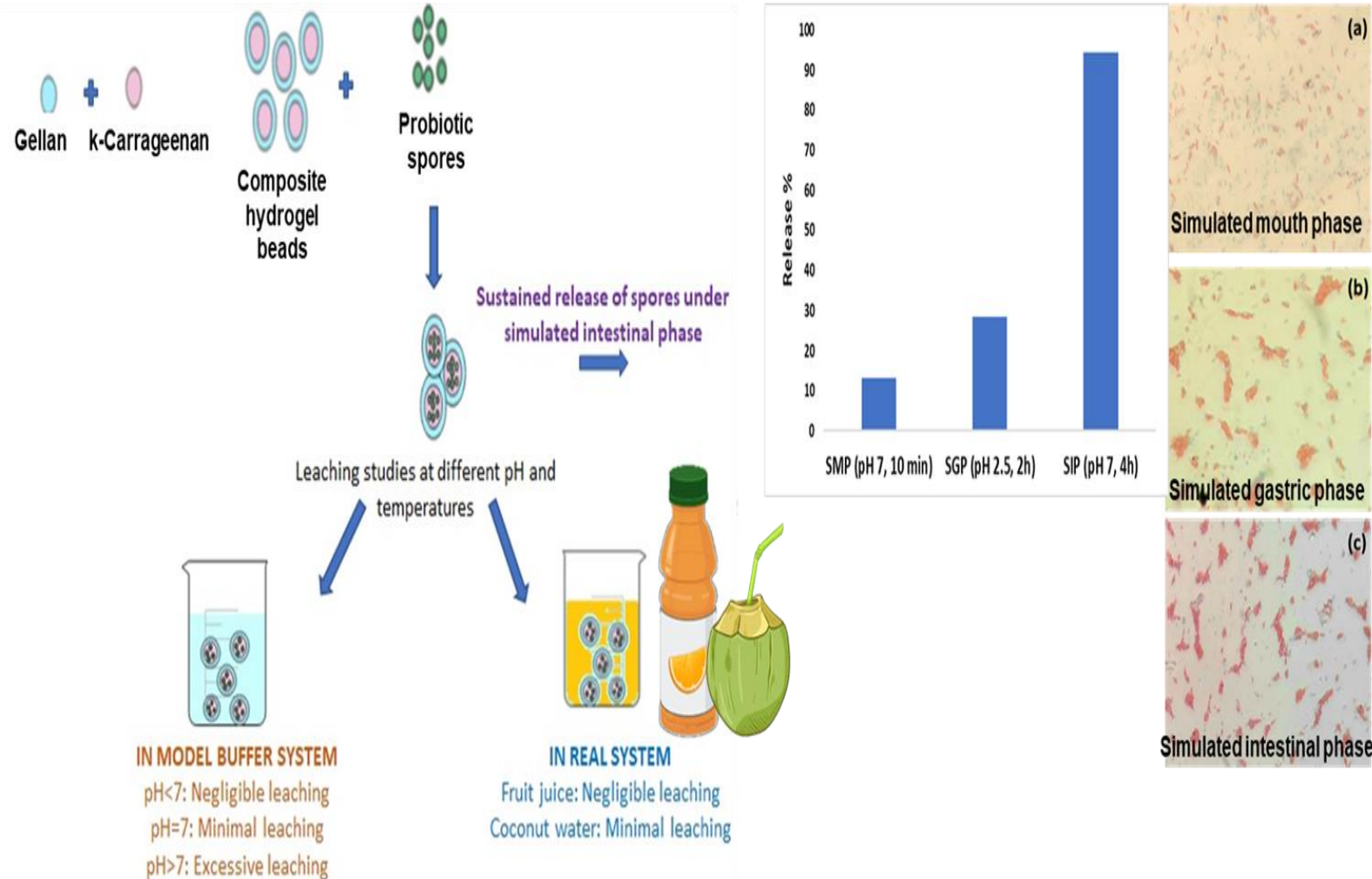
Enhancing the functionality and health benefits of processed foods

Beverage companies looking for adding value to their product with benefit of probiotics

Enhancing the functionality and health benefits of fruit juice products



About the technology Use case: 1

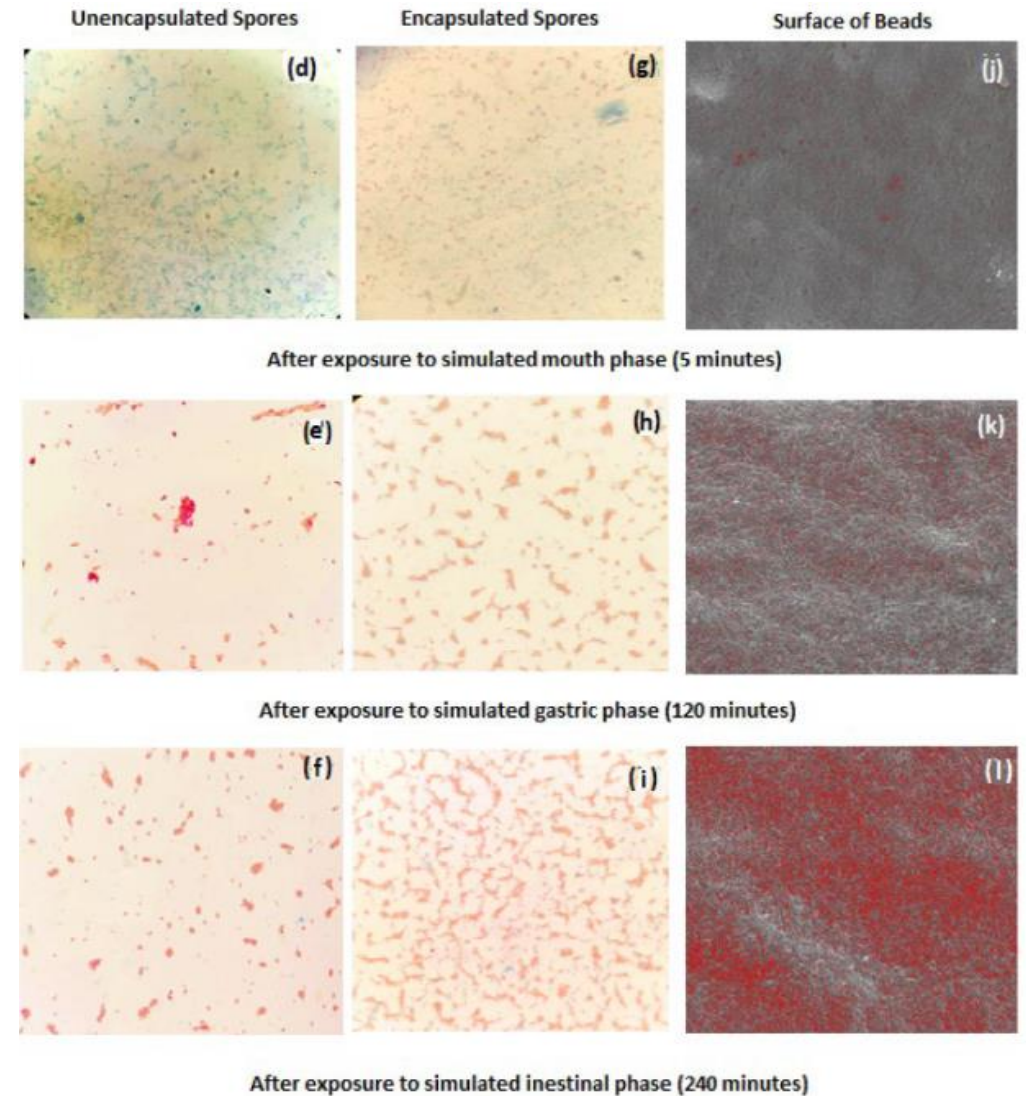
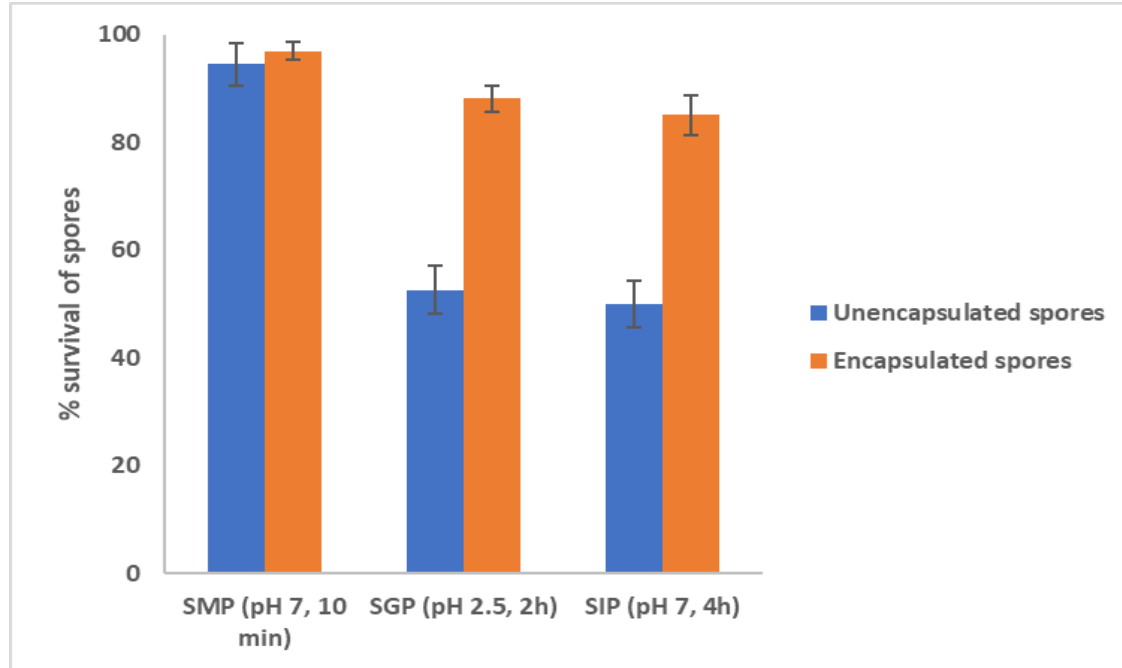


1. Encapsulated probiotic spores as fortification strategy for development of novel functional beverages.

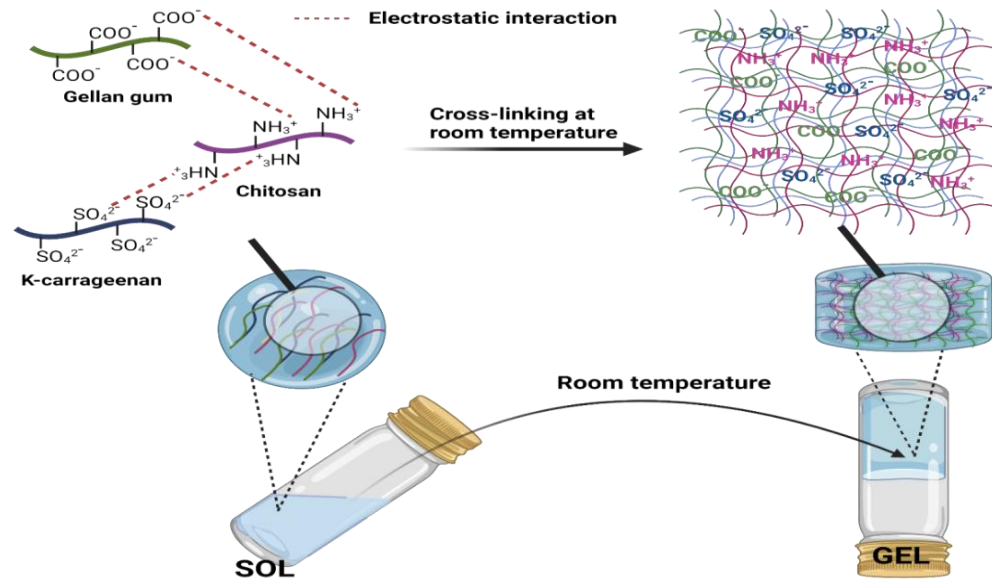
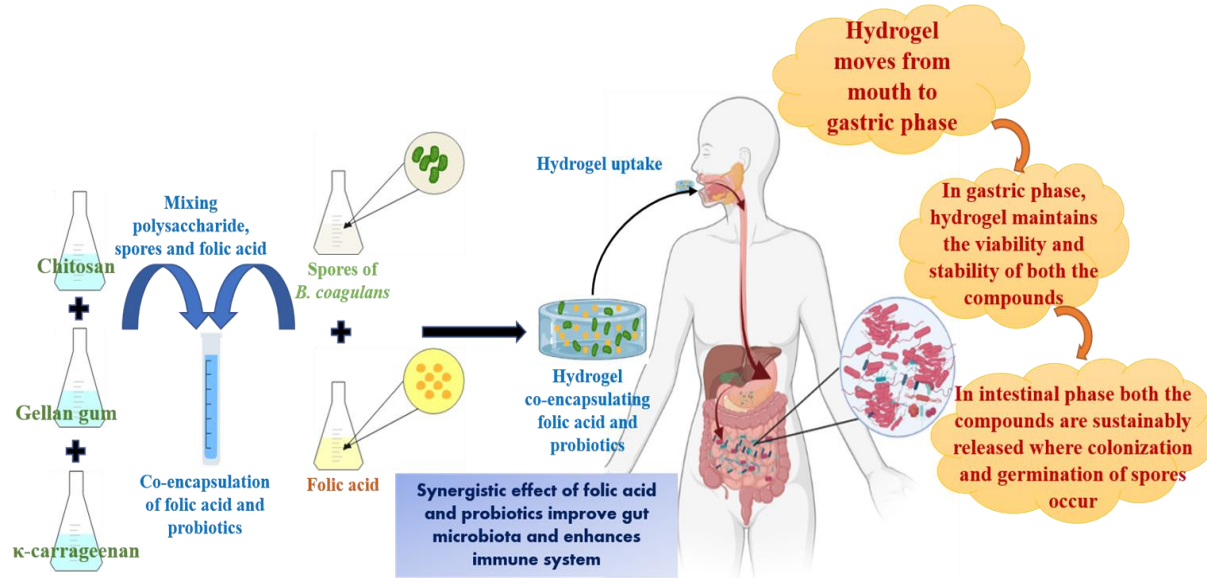
- **Encapsulation** matrix- hydrogel beads made of **Gellan and κ -carrageenan** for probiotic spores site specific delivery.
- **Biocompatible, non-immunogenic, non-toxic**, no harmful chemicals. Encapsulation of spores - leads to
- **Higher survival of spores under highly acidic gastric pH.**
- Increased **bioavailability in gut for its colonisation.**
- **Fruit juice and coconut water** fortified with spore-loaded beads remain **stable up to 42 days at room temperature.**

About the technology Use case: 1

Survival rate of encapsulated and unencapsulated spores in simulated spores



About the technology: Use case :2



2. Gellan/κ-carrageenan/chitosan composite hydrogel for *in vitro* delivery of co-encapsulated bioactive compounds

- Chemicals free → Self assembling, novel **tri-composite hydrogel**
- Highly stable → **Elastic** in nature, **very high swelling capacity (3000% to 7500% approximately)**
- Biodegradable → **Natural, cytocompatible, proven polymers already in use in US FDA approved products.**
- **Sustained release** → pH- responsive, remarkable **encapsulation efficiency**

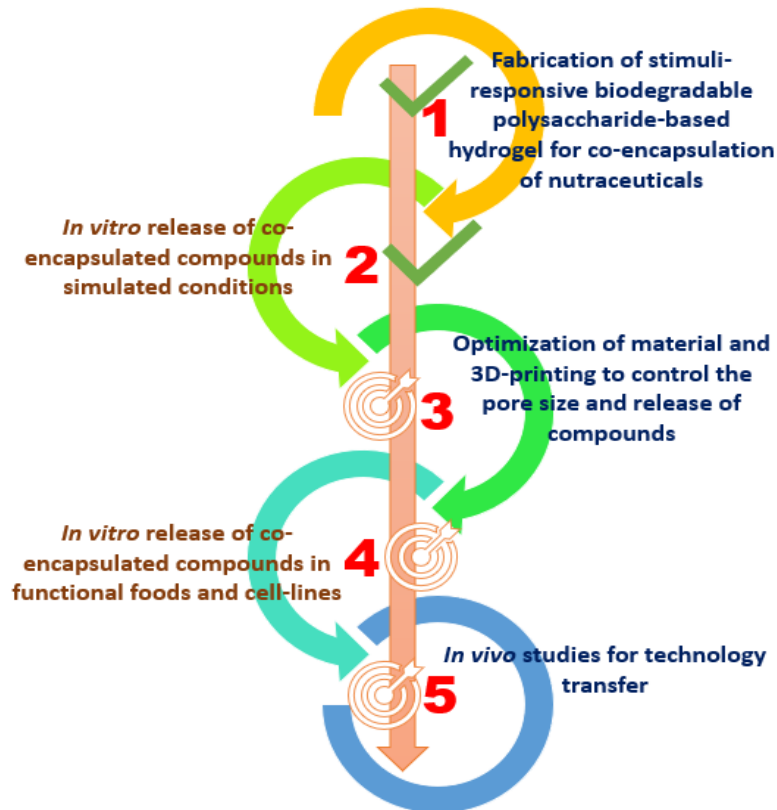
When loaded with: **probiotic spores of *Bacillus coagulans* and co-encapsulated with folic acid (Vit. B9):**

- The matrix maintained **viability and stability** of co-encapsulated folic acid and bacterial spores in **simulated gastric pH** while they were **slowly released in the simulated intestinal phase.**
- In vitro digestion suggested **controlled delivery of compounds at the targeted site** along with **conversion of probiotic spores to vegetative cells.**

Current status

Technology status: (Use case 1 and 2)

Technological platform for encapsulation of nutraceuticals as functional foods (demonstrated at lab scale and in vitro simulated conditions)



Publications

S.no.	Manuscript Title	Journal Name	Year
1	Stimuli-Responsive Polysaccharide-Based Smart Hydrogels and Their Emerging Applications	ACS Industrial & Engineering Chemistry Research	2022
2	Enhanced encapsulation efficiency and controlled release of co-encapsulated <i>Bacillus coagulans</i> spores and vitamin B9 in gellan/κ-carrageenan/chitosan tri-composite hydrogel	International journal of biological macromolecules	2022
3	Microbial Polysaccharide-Based Nanoformulations for Nutraceutical Delivery	ACS Omega	2022
4	Encapsulated probiotic spores as a fortification strategy for development of novel functional beverages	Innovative Food Science & Emerging Technologies	2022
5	Isolation of an exopolysaccharide from a novel marine bacterium <i>Neorhizobium urealyticum</i> sp. nov. and its utilization in nanoemulsion formation for encapsulation and stabilization of astaxanthin	LWT Food Science and Technology	2021
6	Recent advances in composite hydrogels prepared solely from polysaccharides	Colloids and Surfaces B: Biointerfaces	2021
7	Synthesis and rheological characterization of a novel shear thinning levan gellan hydrogel	International journal of biological macromolecules	2020
8	pH mediated rheological modulation of chitosan hydrogels	International journal of biological macromolecules	2020
9	Exploration of polysaccharide based nanoemulsions for stabilization and entrapment of curcumin	International journal of biological macromolecules	2020
10	Understanding the rheology of novel guar-gellan gum composite hydrogels	Materials Letters	2020
11	Synthesis of a novel gellan-pullulan nanogel and its application in adsorption of cationic dye from aqueous medium	Carbohydrate Polymers	2020

Organization CSIR-IMTECH Industrial Collaboration: Recent clientele



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CSIR-Institute of Microbial Technology (IMTech)

National laboratory fore-runner in the domain of microbial biotechnology .

Mission: Address unmet healthcare and industrial needs with state-of-the-art processes and platforms

Expertise in the areas of:

- Bioprocess and fermentation technology,
- Cloning, expression and scale up of recombinant / engineered proteins
- Molecular microbiology, Immunology of infectious diseases,
- Yeast Genetics,
- Screening of microorganisms for novel enzymatic activities and strain improvement,
- Bioinformatics & high end computational biology,
- Microbial taxonomy and metagenomics.

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Team



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- Expertise in Bioprocess Development and Scale up, Fermentative production of polysaccharides, Polysaccharide based biomaterials.
- More than 2 decades of experience in the industry and academia.
- **Successfully delivered projects to industries like Panacea Biotech, IFB Agro, Excel Biotech, Dhampur Sugar Mill and many more.**

CSIR-Institute of Microbial Technology (IMTech) National laboratory fore-runner in the domain of microbial biotechnology

Key assets and strengths of the team:

- ◆ **35+** publications in bioprocess development and microbial technology.
- ◆ Fermentative production of commercially important biomolecules special interest novel exopolysaccharides for diverse industrial sectors.
- ◆ Development of economically feasible bioprocess for production of Pullulan optimized for 500L fermenter.
- ◆ Application development of polysaccharide-based materials like hydrogels focusing towards food sectors.

Next Steps



- The team has invented a new process for natural polysaccharide-based smart hydrogel systems to enhance shelf-life and controlled delivery of nutraceuticals. The process has been demonstrated at lab scale
- The next steps are to identify an industrial partner for co-development of the technology involving process optimization, develop purification methods, scale up to pre-commercial levels, carry out detailed testing and produce trial quantities for customer inputs

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 > Market data

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3. <https://www.grandviewresearch.com/industry-analysis/probiotic-drink-market>
4. <https://www.databridgemarketresearch.com/reports/global-fruit-based-probiotic-drinks-market>
5. (Li et al., 2021; Wong et al., 2021)
6. ([Franco, Tommasina, & Pietro, 2016](#); [Goff & Guo, 2020](#)). ([Seisun & Zalesny, 2021](#); [Thies, 2012](#))
7. ([Mackie, 2012](#))