Microencapsulation of Probiotics

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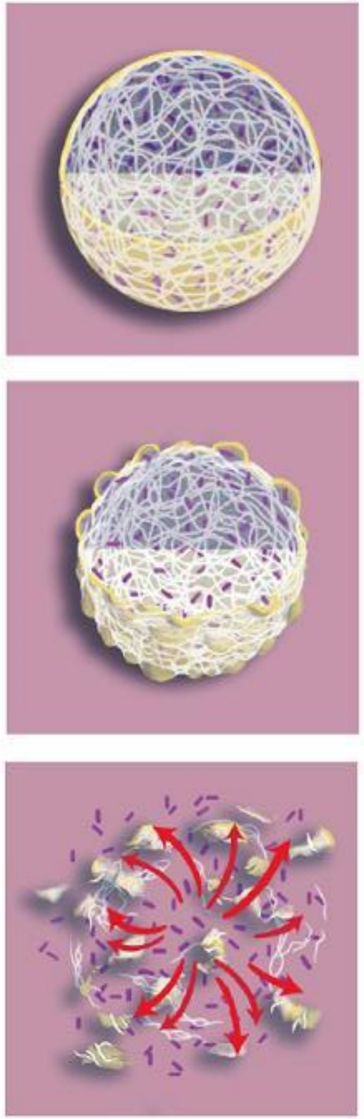
Outline

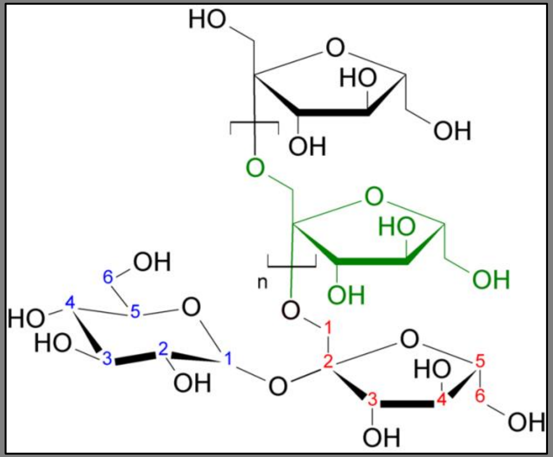
- **Probiotic Benefits and Claims in Products**
- **Applications in Food/Feed and Beverages**
- **Keys to Delivery (Heat, Humidity, Oxygen)**
- **Review of Various Encapsulation Methods**



Probiotics vs. Prebiotics

Probiotics
Live microbial supplements that have beneficial effects on the consumer

Prebiotics
Feed the good that already populate the digestive system



"Live microorganisms which, when administered in adequate amounts confer a health benefit on the host"
FAO/WHO Expert Consultation Report, 2001.

Human Microbiome Project

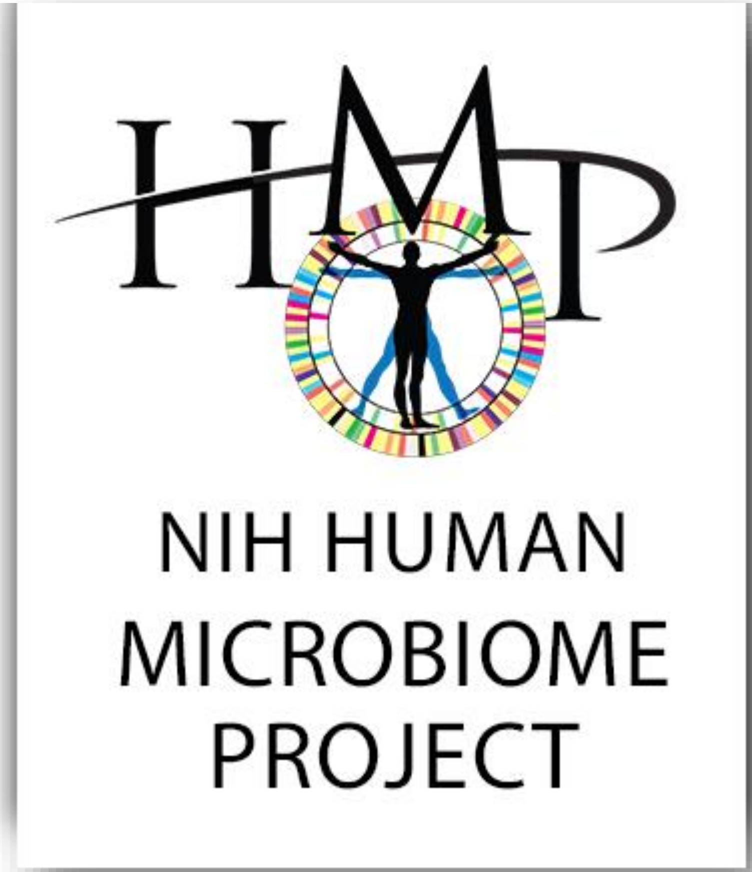


Image source: (*Http://Www.Actionbioscience.Org/Images/Microbes_Over_Time_Sized.Jpg*)

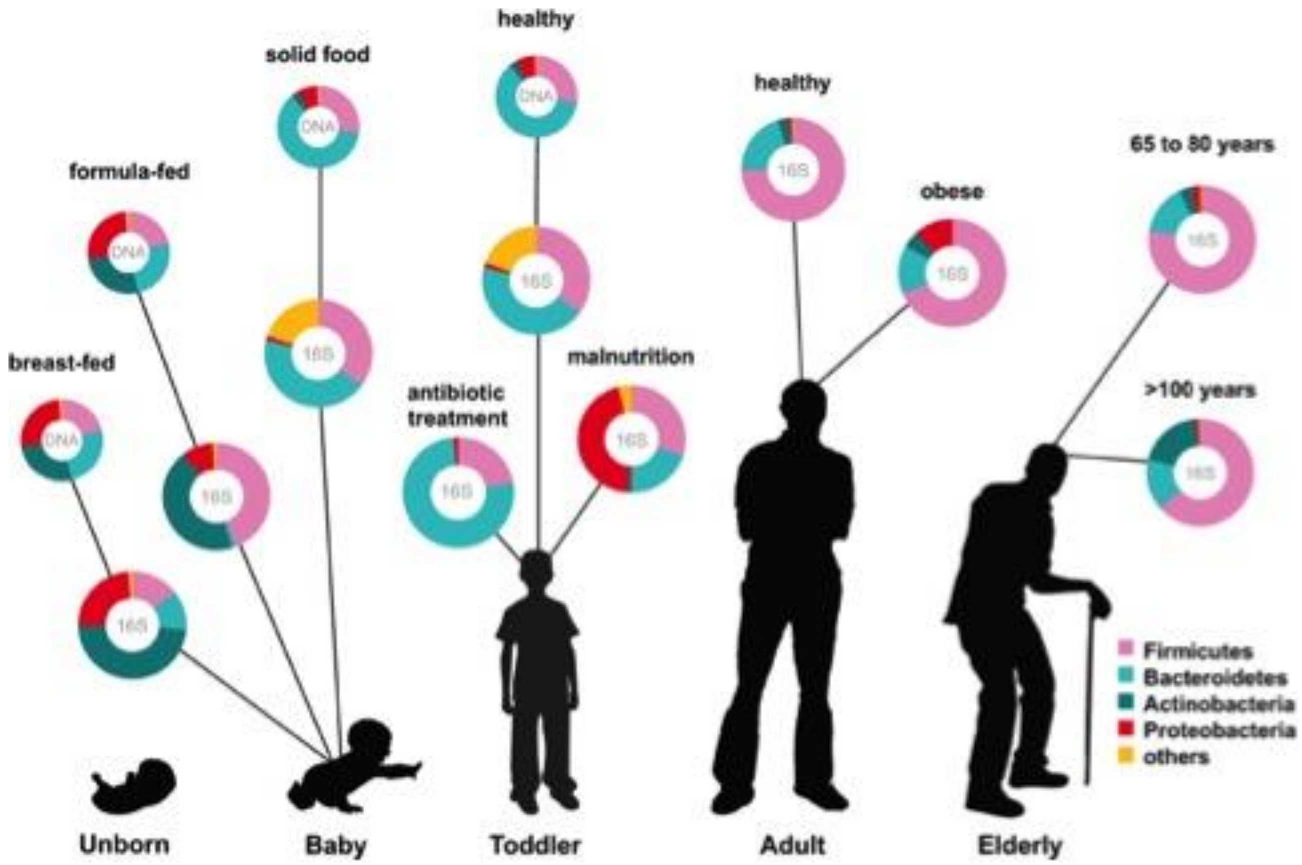
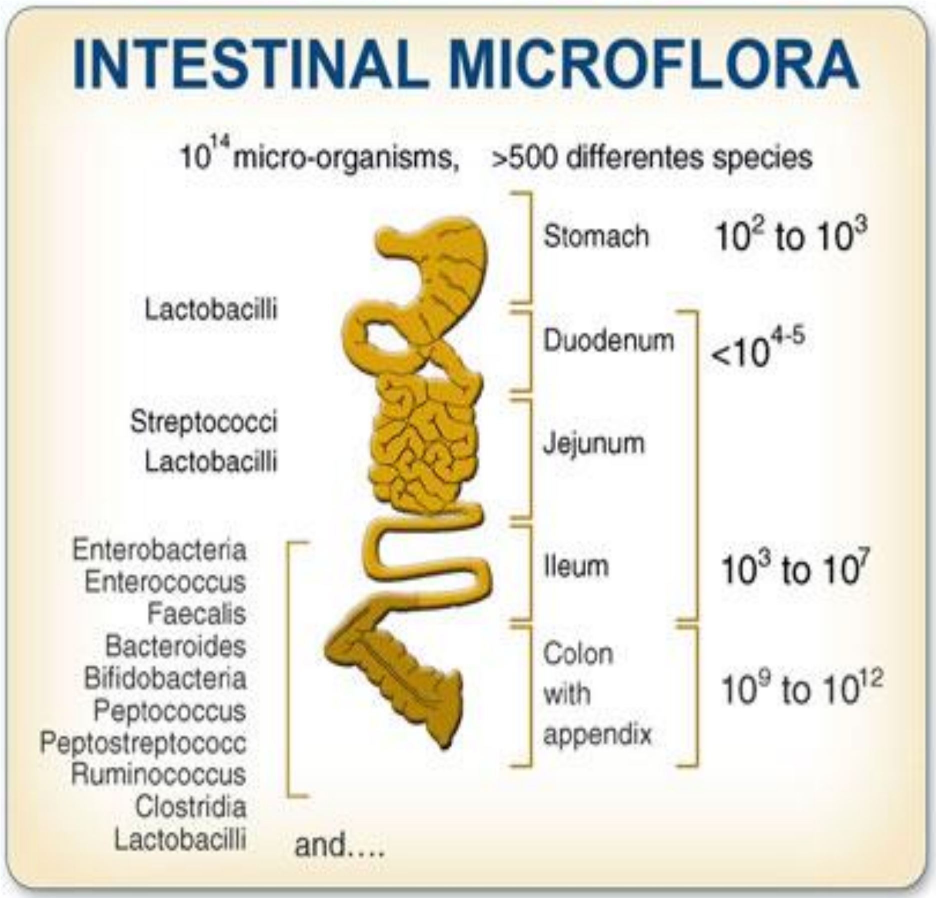
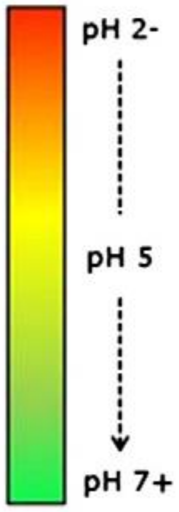


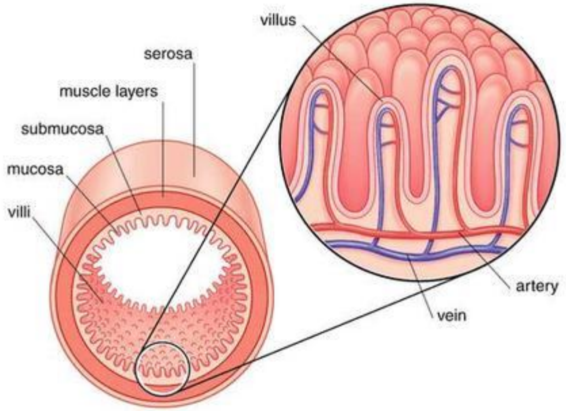
Image source: Ottman N, Smidt H, de Vos WM and Belzer C (2012) The function of our microbiota: who is out there and what do they do? Front. Cell. Inf. Microbio. 2:104. doi: 10.3389/fcimb.2012.00104.

Probiotic Benefits: Promoting Digestive Health (Probiotics and Prebiotics)

<u>Digestive health is the most studied and documented benefit of probiotics</u>







Eckburg, PB et al. Science 2005:308;1635-8

Probiotic Benefits: Supporting the Immune System

Probiotics release soluble factors and antimicrobial compounds triggering signaling cascades that activate underlying immune cells

A clinical study demonstrated a significant reduction in the frequency of atopic diseases in infants supplemented with *Lactobacillus GG (Kalliomäki et al., 2001, 2007)*

Probiotics relieve and improve conditions of those suffering from autoimmune diseases, such as rheumatoid arthritis, type 1 diabetes, multiple sclerosis, lupus psoriasis etc. *(See a Review Article by Herichr, R. and Levkut M.- Vet. Med. – Czech, 47, 2002 (6): 169–180)*

Probiotic Claims in Dietary Supplements

- **Structure/function statements in dietary supplement may not claim to diagnose, mitigate, treat, cure or prevent a disease.**

- **Dietary supplements making disease claims are deemed to be drugs**

- **Structure/function statements for pre-probiotics could be related to immune function, intestinal health, bowel function.**

Probiotic Supplement Challenge: Packaging Cost and Storage Conditions

- Preservation (storage shelf life)
    - Humidity
    - Temperature
    - Oxidation
- Gastric Protection
- Post Gastric Release

Probiotic Challenges in Food: A Wide Variety of Products

Process and Storage Challenges

Treats

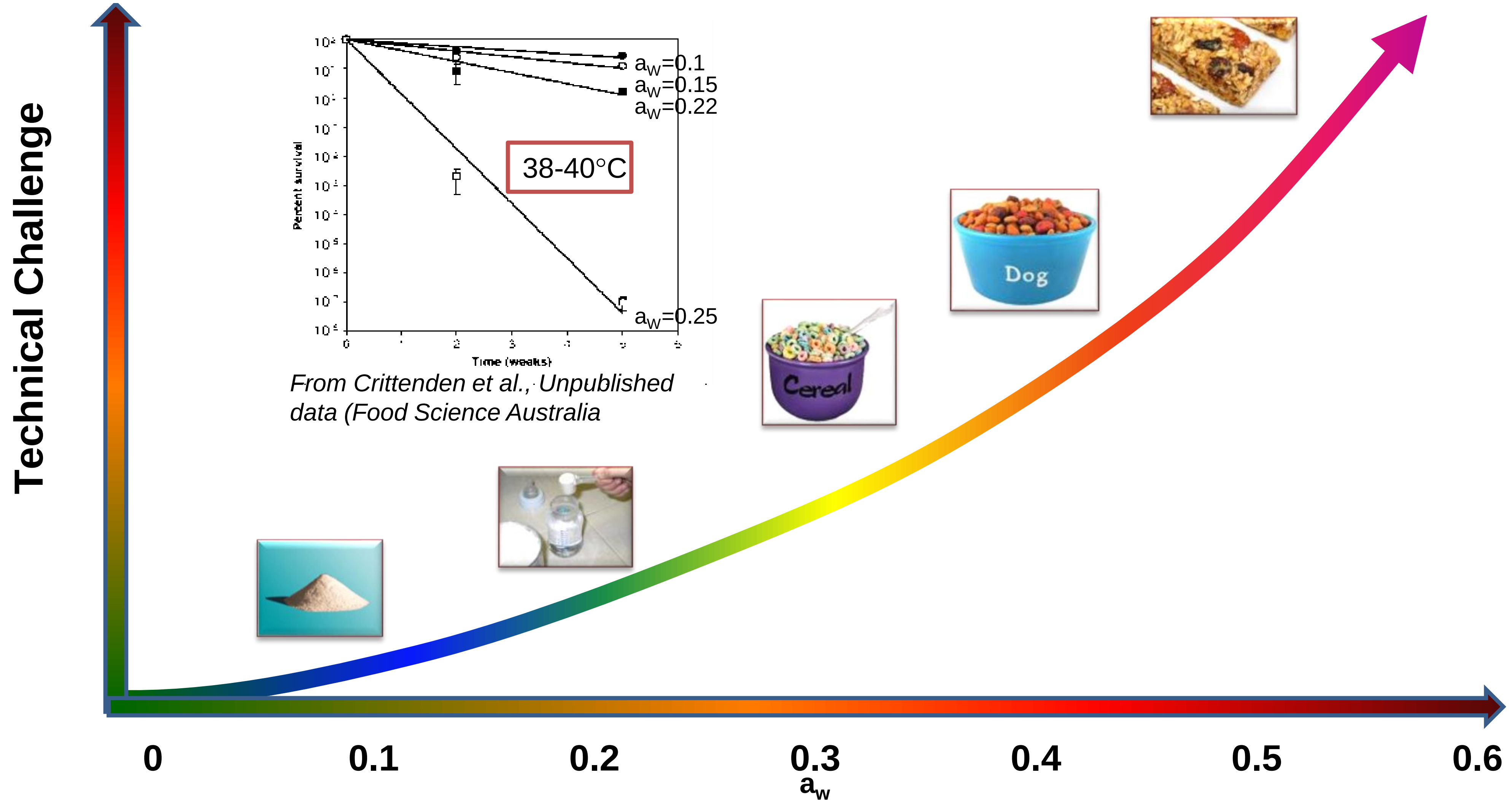
Beverages (Cold or Hot)

Ice Cream

Yogurts

Baby Cereals

Shelf Storage Challenge: Water Activity



From Crittenden et al., Unpublished data (Food Science Australia

Can Encapsulation Improve Probiotic Survival in Dry Products?

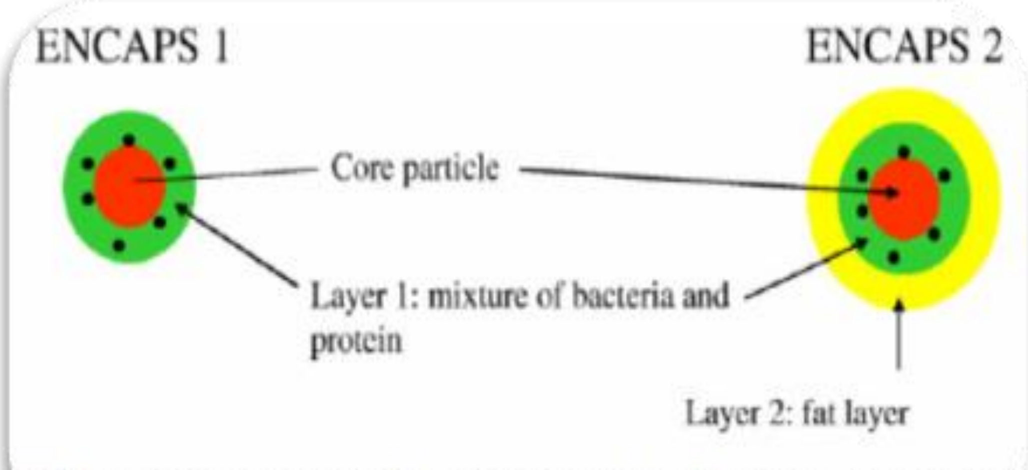
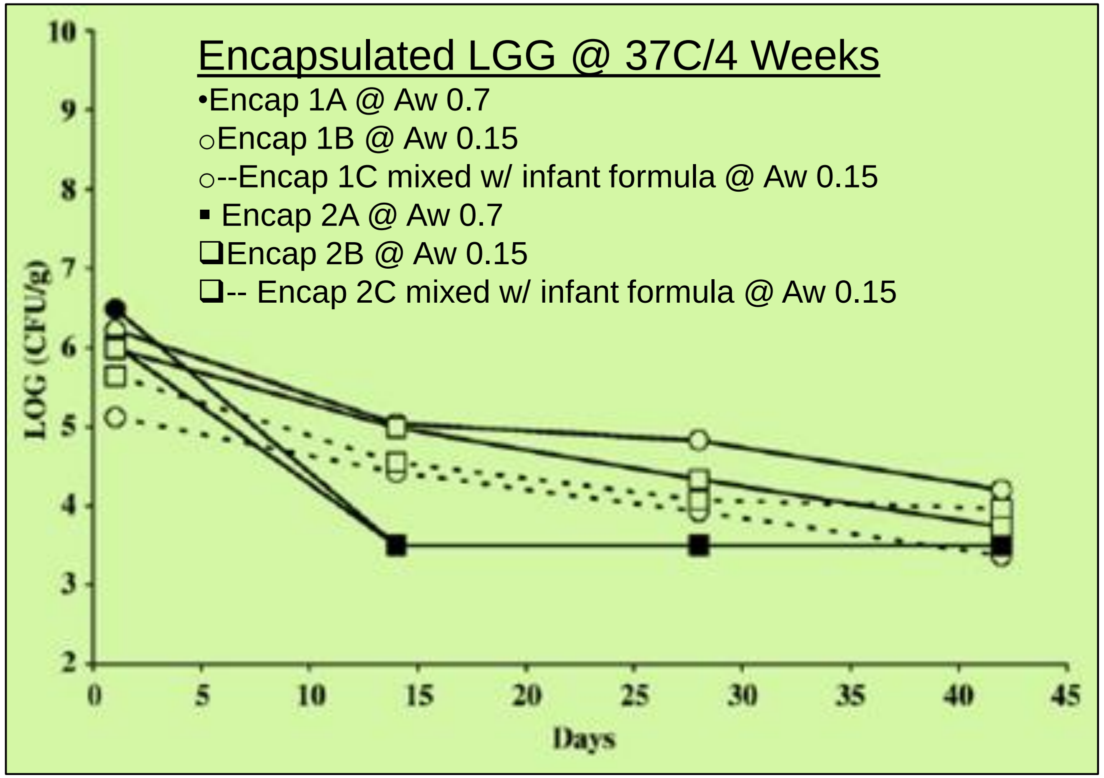


Fig. 1. Schematics of the two batches of encapsulated LGG (Encaps 1 and Encaps 2).

"…There is no quick fix for maintaining cell survival under the high moisture conditions encountered by bacteria in food matrices."



…A multifaceted approach is warranted incorporating emerging knowledge of probiotics… as well as preservation technologies designed to improve and maintain probiotic survival during food processing, storage, and consumption."

F. Weinbreck et al. / International Journal of Food Microbiology 136 (2010) 364–367

Water-vapor and Oxygen Permeability of Polymer Films

Table 4. Comparison of the oxygen permeability of edible polymer films and conventional synthetic polymer films

Film type[a]	Test conditions	Permeability[b]	Ref.
Cellulose-based:			
MC	24°C, 50% RH	97	21
HPMC	24°C, 50% RH	272	21
MC	25°C, 52% RH	90	22
Starch-based:			
Amylomaize starch	25°C, <100% RH	<65	23
Hydroxypropylated amylomaize starch	25°C, <78% RH	~0	24
Protein-based:			
Collagen	RT, 0% RH	<0.04–0.5[c]	25
Collagen	RT, 63% RH	23.3	25
Collagen	RT, 93% RH	890	25
Zein : PEG + glycerol (2.6 : 1)	25°C, 0% RH	38.7–90.3	26
Gluten : glycerol (2.5 : 1)	25°C, 0% RH	6.1	27
Soy protein isolate : glycerol (2.4 : 1)	25°C, 0% RH	6.1	28
Whey protein isolate : glycerol (2.3 : 1)	23°C, 50% RH	76.1	29
Whey protein isolate : sorbitol (2.3 : 1)	23°C, 50% RH	4.3	29
Synthetic:			
LDPE	23°C, 50% RH	1870	6
HDPE	23°C, 50% RH	427	6
Polyester	23°C, 50% RH	15.6	30
EVOH (70% VOH)	23°C, 0% RH	0.1	6
EVOH (70% VOH)	23°C, 95% RH	12	6
PVDC-based films	23°C, 50% RH	0.4–5.1	6

[a]See Box 2 for polymer abbreviations
[b]Units for oxygen permeability are $cm^3\,\mu m/m^2\,d\,kPa$ (see Table 1)
[c]Based on a percentage of the oxygen permeability of PVDC-based film; Ref. 6
RT, Room temperature
RH, Relative humidity

None of the bio or synthetic polymers is 100% impermeable.

Polymers having good WVP may not necessarily have good O_2P

Table 18.2 Properties of selected synthetic and biopolymer films for comparison to myofibrillar protein films (Krochta *et al.*, 1994; Cuq, 2002)

Film	Tensile strength (MPa)	Elongation (%)	WVP*	O_2P**
Polyester	178	85	0.02	12
Polyvinyl chloride	93	30	1.2	23
Low-density polyethylene	13	500	0.04–0.05	1003
High-density polyethylene	26	300	0.014	224
Hydroxypropyl cellulose	15	33	6.2	300
Wheat gluten	3.3	192	5.1	1290
Soy protein	3.6	160	194	14
Corn zein	3.9	213	6.5	35
Fish myofibrillar protein	17	23	3.9–3.8	1–873***

* WVP (water-vapor permeability) ($\times 10^{-12}$ $mol \cdot m \cdot /m^2 \cdot s \cdot Pa$)
** O_2P (oxygen permeability) ($\times 10^{-18}$ $mol \cdot m \cdot /m^2 \cdot s \cdot Pa$)
*** 1 measured under dry conditions, 873 measured under high relatively humidity.

Encapsulation Methods: Matrix Formation

Requirements: cost effective, scalable, gentle process

<u>Drip Capture</u>

- Med viscosity OK
- 400-1200 micron
- 0.5 Kg/nozzle/hr

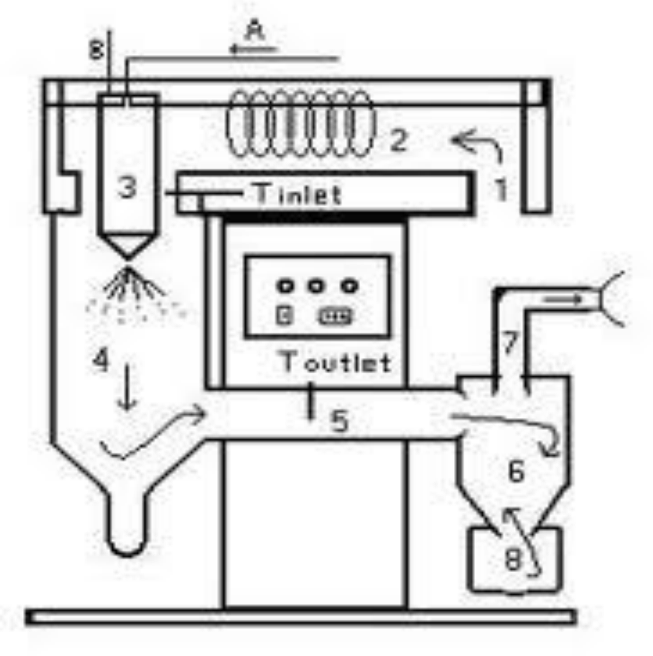
<u>Spray Capture</u>

- 60 Kg/Nozzle/hr
- 50-200 microns
- Sterility and harvest difficulties

Encapsulation Methods: Core-Shell Coating

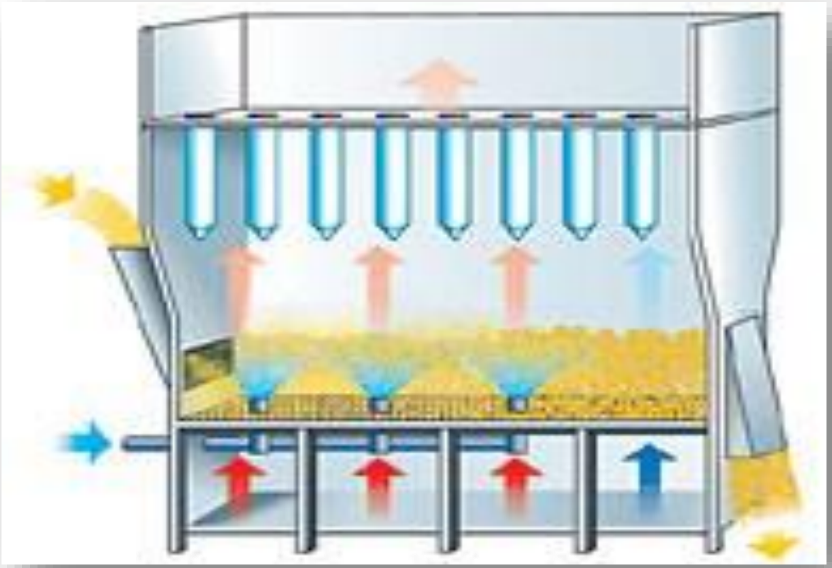
Spray Drying

- 60 Kg/Nozzle/hr
- 50-200 microns
- High shear and temp exposure



Fluidized Bed Coating

- High through put
- Double processing
- High humidity and temp exposure



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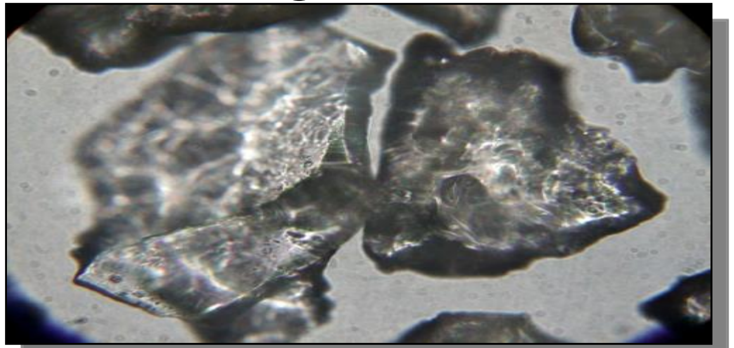
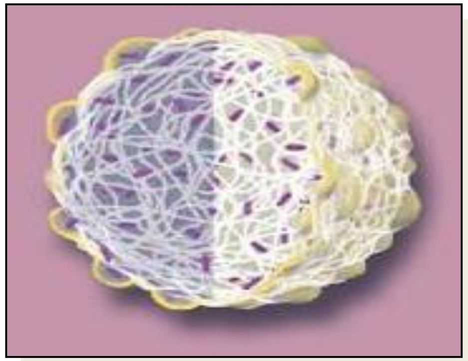
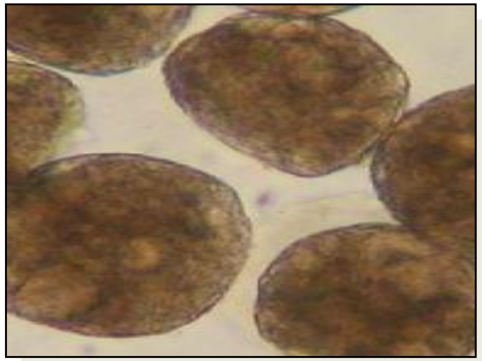
ABN Encapsulation Technologies

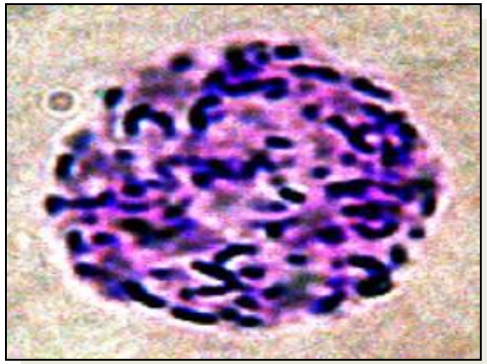
1-Stabilize by High T_g Materials



2-Protect with Polymeric Matrix







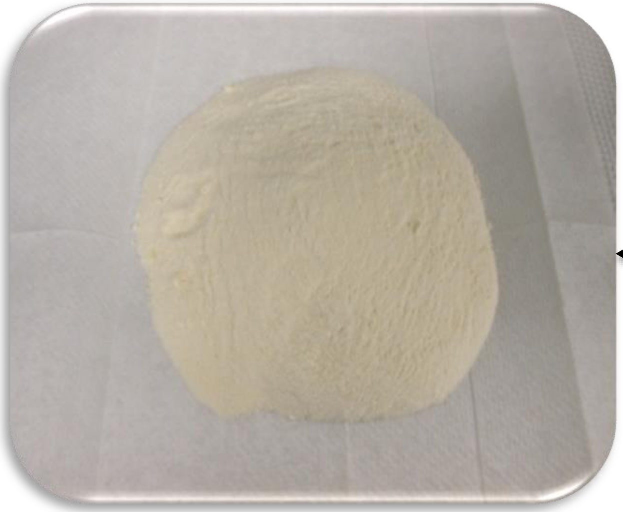
ABN's Dehydration Process

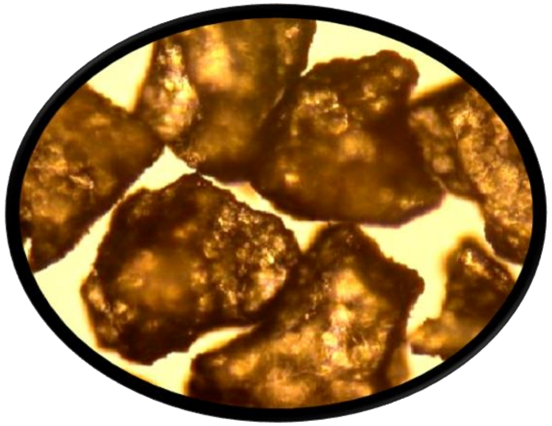
Matrix Formation

Shredding

Dehydration

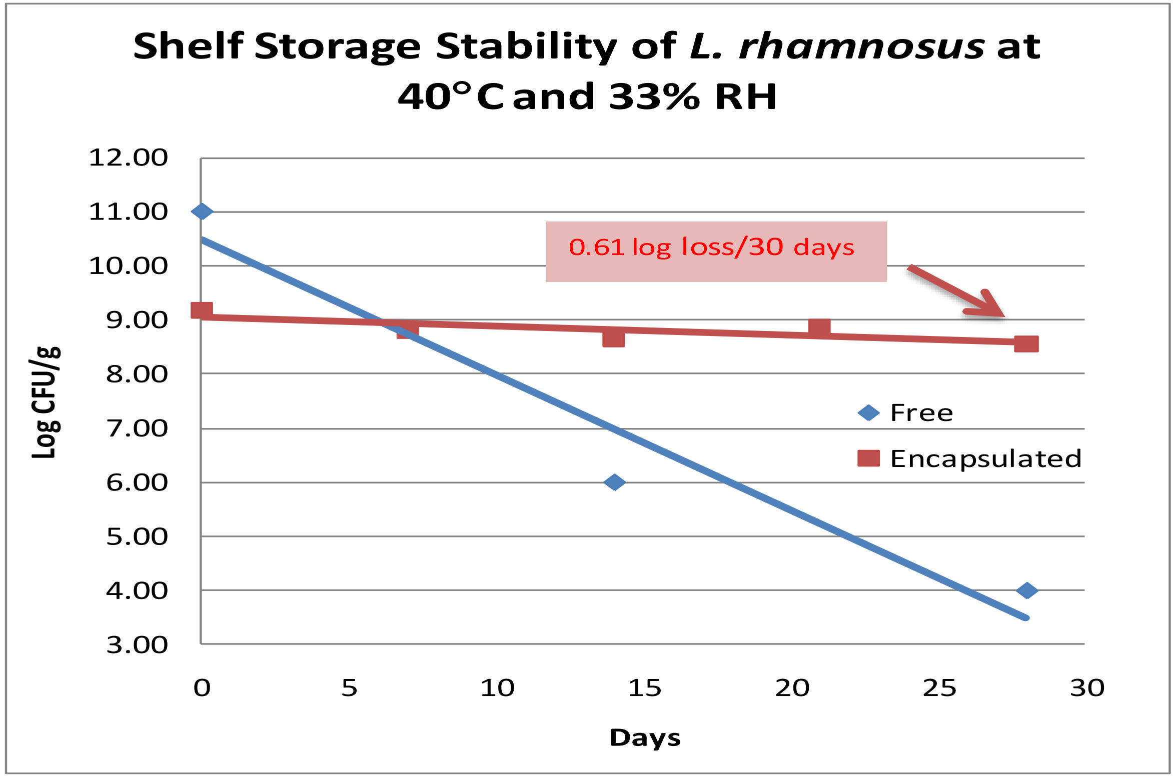
Milling

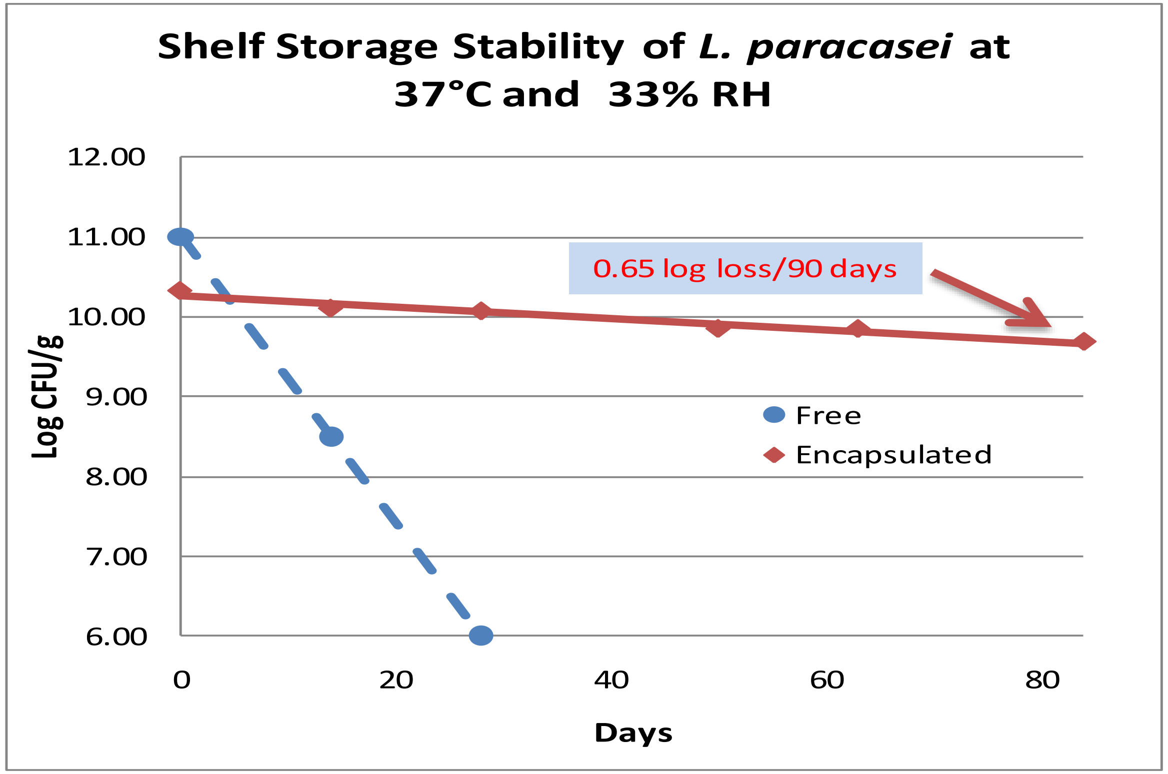




Magnified Particles

ABN Stabilized Probiotics: Storage Stability in Elevated Temperature (24-40°C) and Humidity (33% RH)





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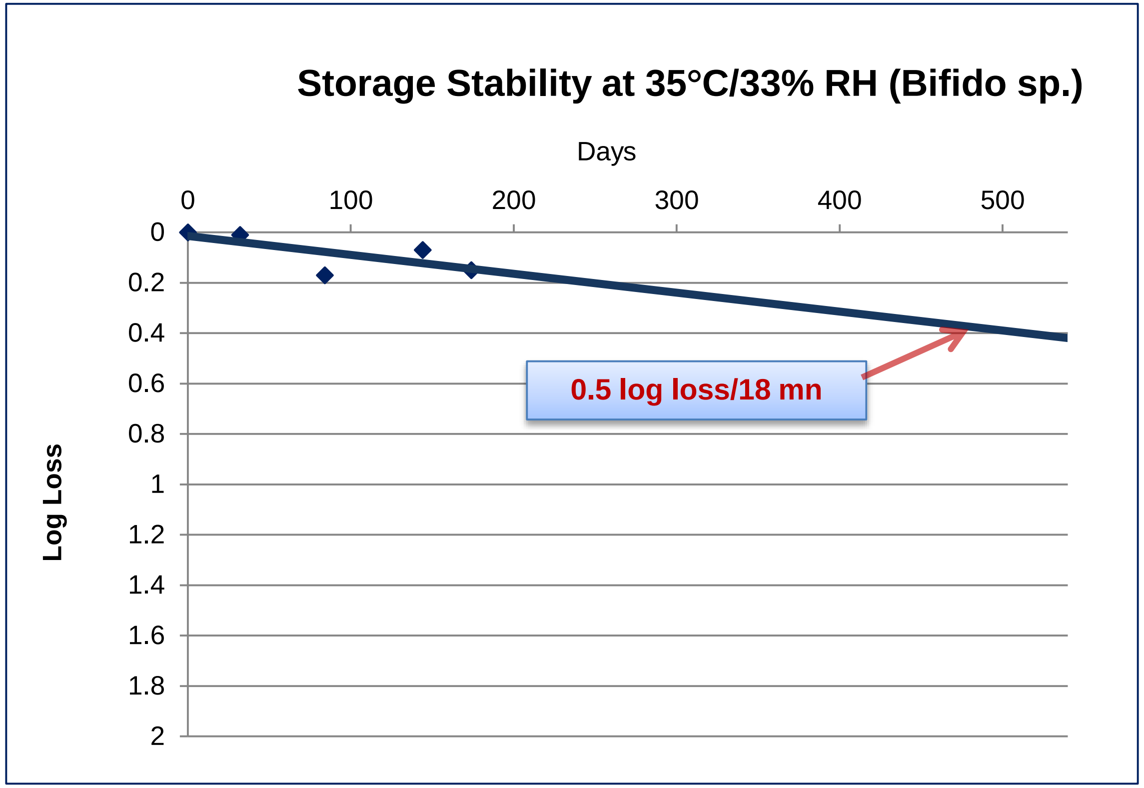
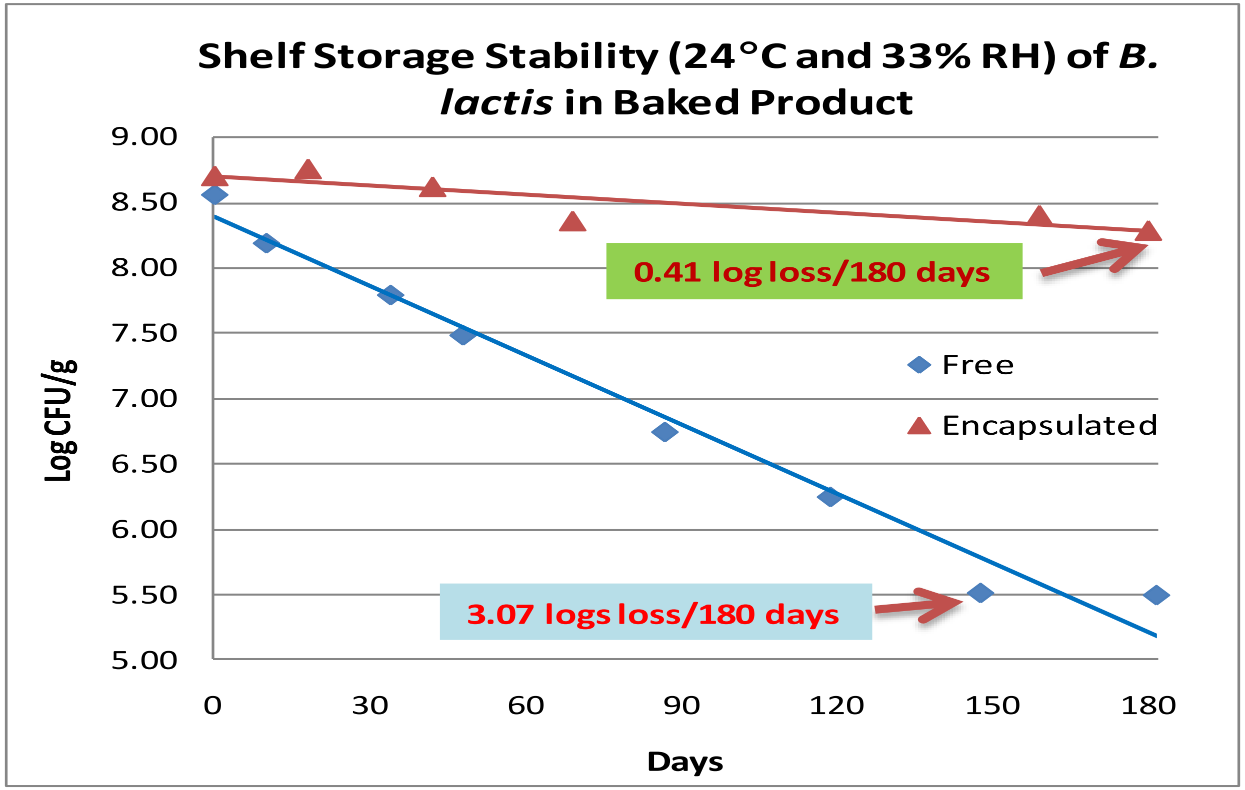
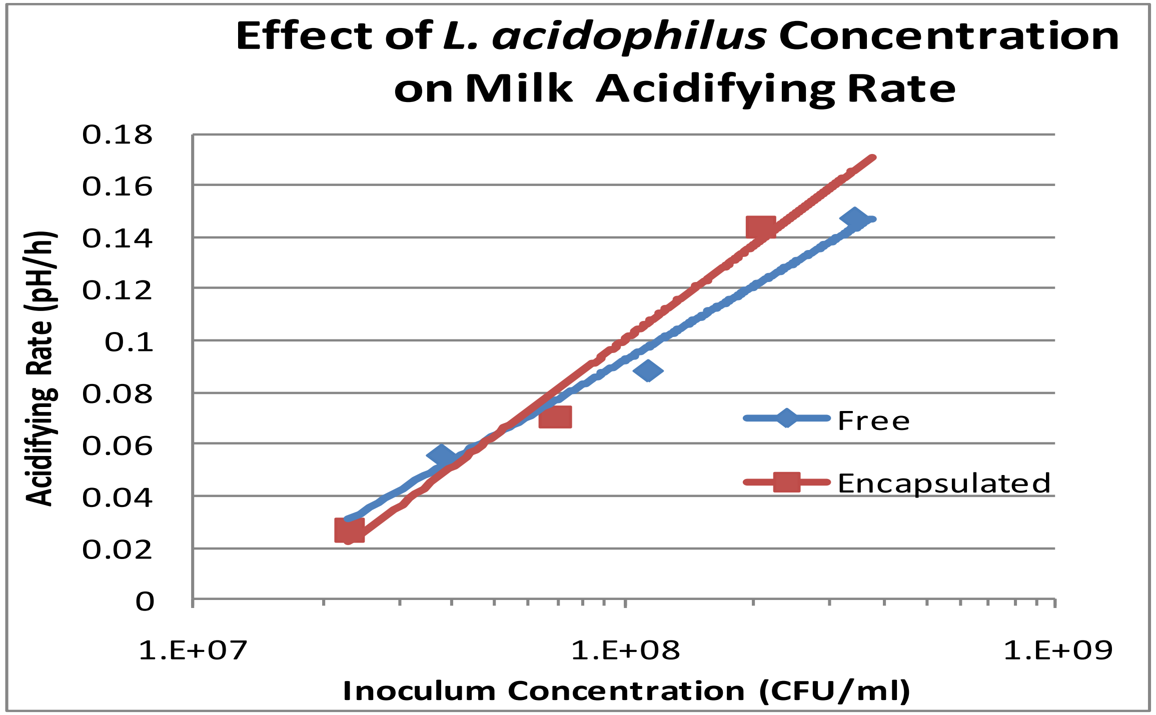
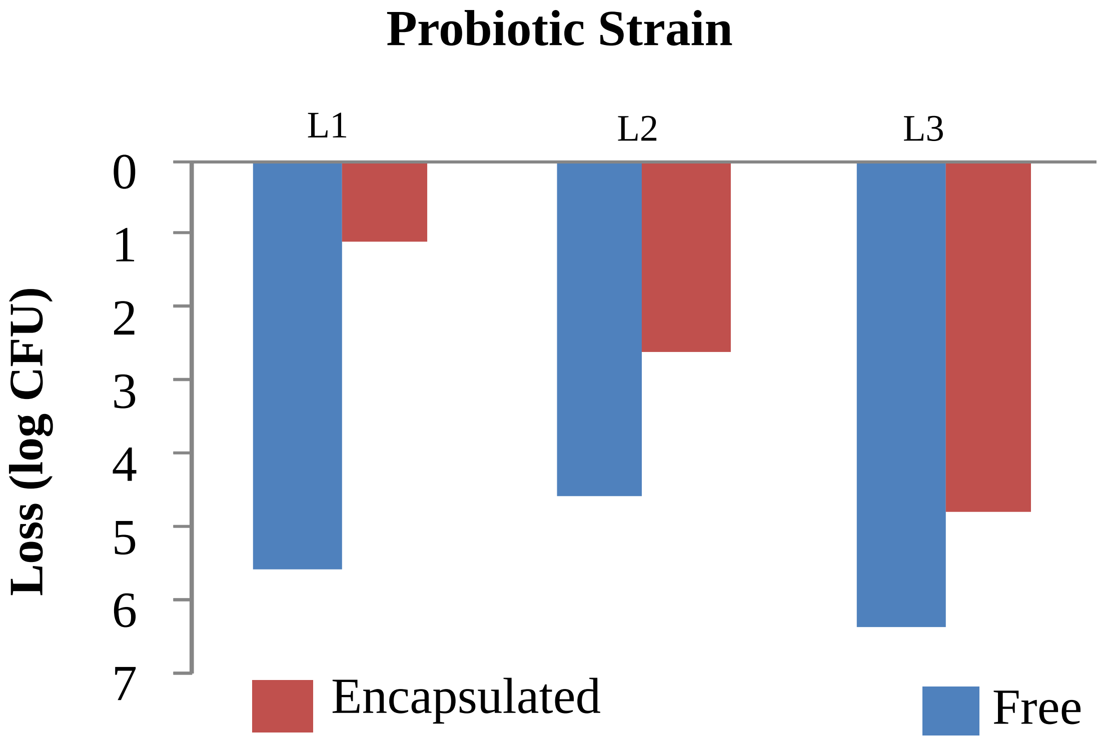




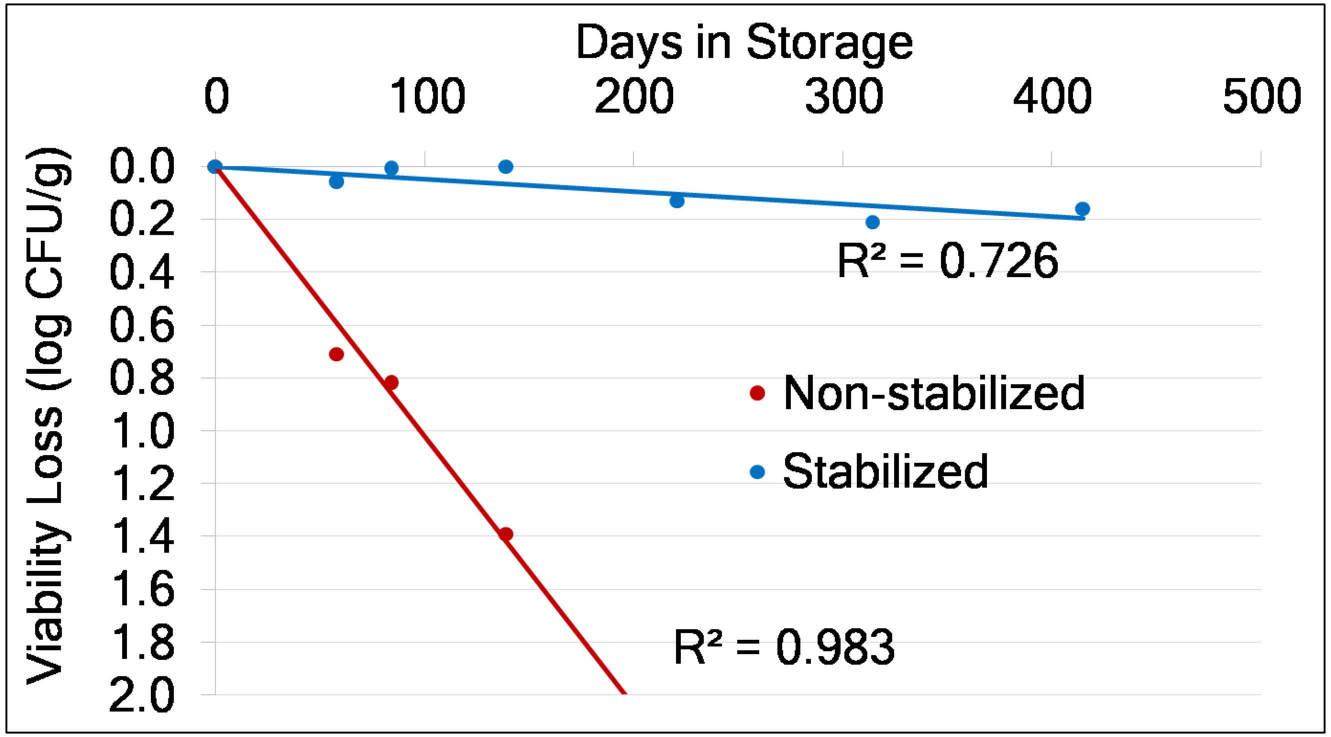
ABN Stabilized Probiotics: Gastric Stability (in a Gastric Juice Model)





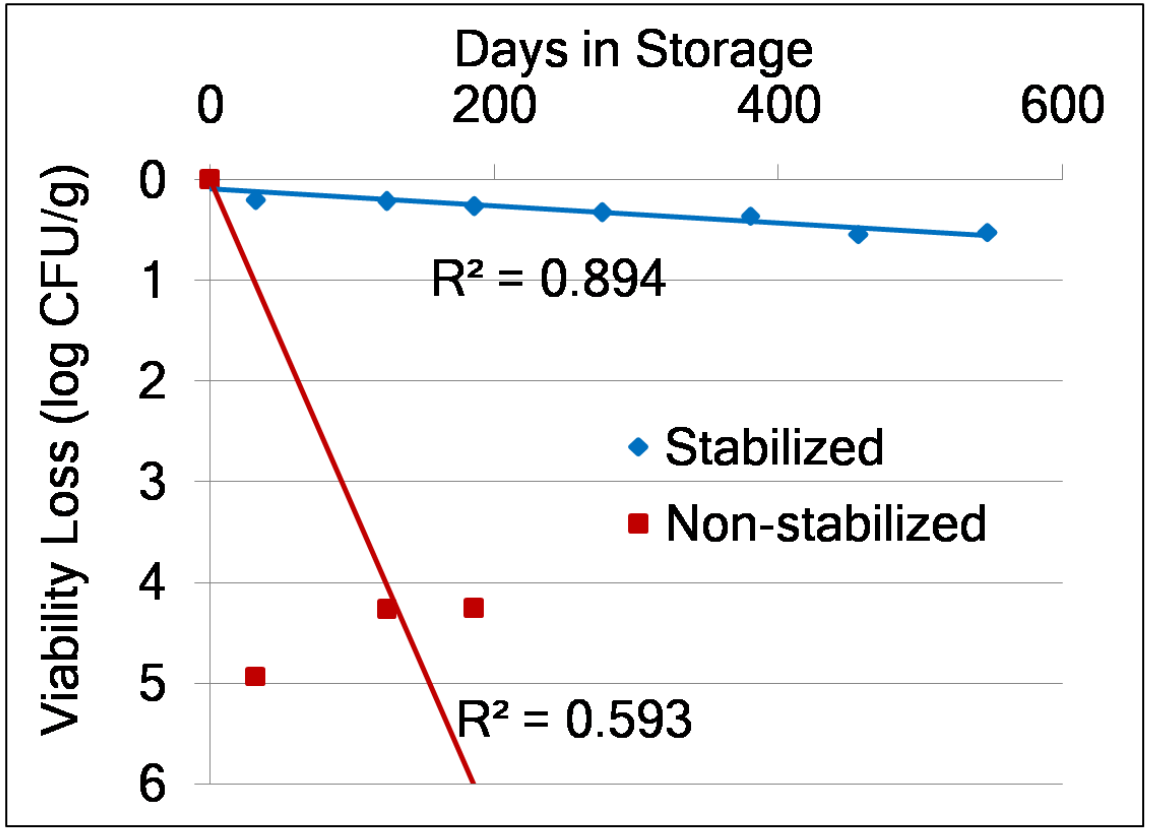
2 hours incubation in simulated gastric juice at 37 ℃ and pH=1.2.

ABN Stabilized Probiotics: Stability in Nut Butter Spread



Survival of *Bifido* sp. in peanut butter spread (**A_w 0.24**) incubated at 25°C. Non-stabilized bacteria lost over 1 log CFU/g within 3 months, the stabilized bacteria survived for more than a year with a loss of 0.2 log CFU/g.

ABN Stabilized Probiotics: Stability in Powdered Drink Mix



Survival of *Lactobacillus paracasei* in powder beverage (**A_w 0.26**) incubated in closed packaged at 25°C for 18 months. Non-stabilized bacteria lost over 4 log CFU/g within one month, the stabilized bacteria survived for 18 months with a loss of about 0.5 log CFU/g.

Summary

- **Claims**: Digestive health, Immune Support, Oral Health, Urogenital Health, Weight Management, etc.
- **Applications:** Supplements, Treats, Cereals, Beverages, Ice cream, Yogurt, Companion Animals.
- **Keys to Delivery:** Temperature, Humidity, Oxidation, Industrial process destruction, Gastric destruction, Targeted delivery.
- **Encapsulation Methods:** Freeze drying, Spray capture, Spray drying, Fluidized bed coating, preservation formulas.
- **Encapsulation Technologies:** High Tg Materials, Polymeric Matrixes, Controlled Dehydration.

Additional Information

•International Probiotics Association (IPA) news letters, events and general information: http://internationalprobiotics.org/

•FAO/WHO. Probiotics in food: Report of a Joint FAO/WHO Expert Consultation on Evaluation of Health and Nutritional Properties of Probiotics in Food. In FAO

•FOOD AND NUTRITIONPAPER-85, 2006. ISBN 92-5-105513-0: ftp://ftp.fao.org/docrep/fao/009/a0512e/a0512e00.pdf

•European Food Safety Authority (EFA). Various publications on probiotics: http://www.efsa.europa.eu/

Publications

•Handbook of Probiotics and Prebiotics, 2nd Edition. 2008. Eds. Yuan Kun Lee and Seppo Salminen. Wiley-Blackwell Publication.

•PROTECTION AND DELIVERY OF PROBIOTICS FOR USE IN FOOD. In: Microencapsulation in the Food Industry: A Practical Implementation Guide. Eds; Sobel, R.M., Versic, R.J., Gaonkar, A.G. Elsevier Inc., in press.

•Kailasapathy K. 2002. Microencapsulation of probiotic bacteria: Technology and potential applications. *Cuur. Issues Intest. Microbiol. 3:39-48*.

•Encapsulation of Probiotics for use in Food Products. In: Encapsulation Technologies for Active Food Ingredients and Food Processing. Eds; Manojlović, V., Nedović, V.A., Kailasapathy, K., Jan Zuidam, N. Springer New York. 2010, pp 269-302

Thank you!

feeding the minds that feed the world

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