KERRY

FDC 2024 Annual Technical Conference

Do Probiotics like ice cream?

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ProActive Health-Kerry
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Kerry ProActive Health

Kerry is radically rethinking the supplements, functional food & beverage.

By combining **premium, clinically proven** ingredients with our **unmatched ingenuity** in taste, we're creating leading-edge health and wellness solutions that blend the very best of **science, sourcing** and **sensory**.

Ingredients designed with **consumer need** and **positive impact** front of mind.

Kerry's ProActive Health Journey

Kerry's rich food heritage spans more than 50 years. Our ProActive Health portfolio has developed to meet the needs of today's wellness consumer.

Founded
1972 KERRY

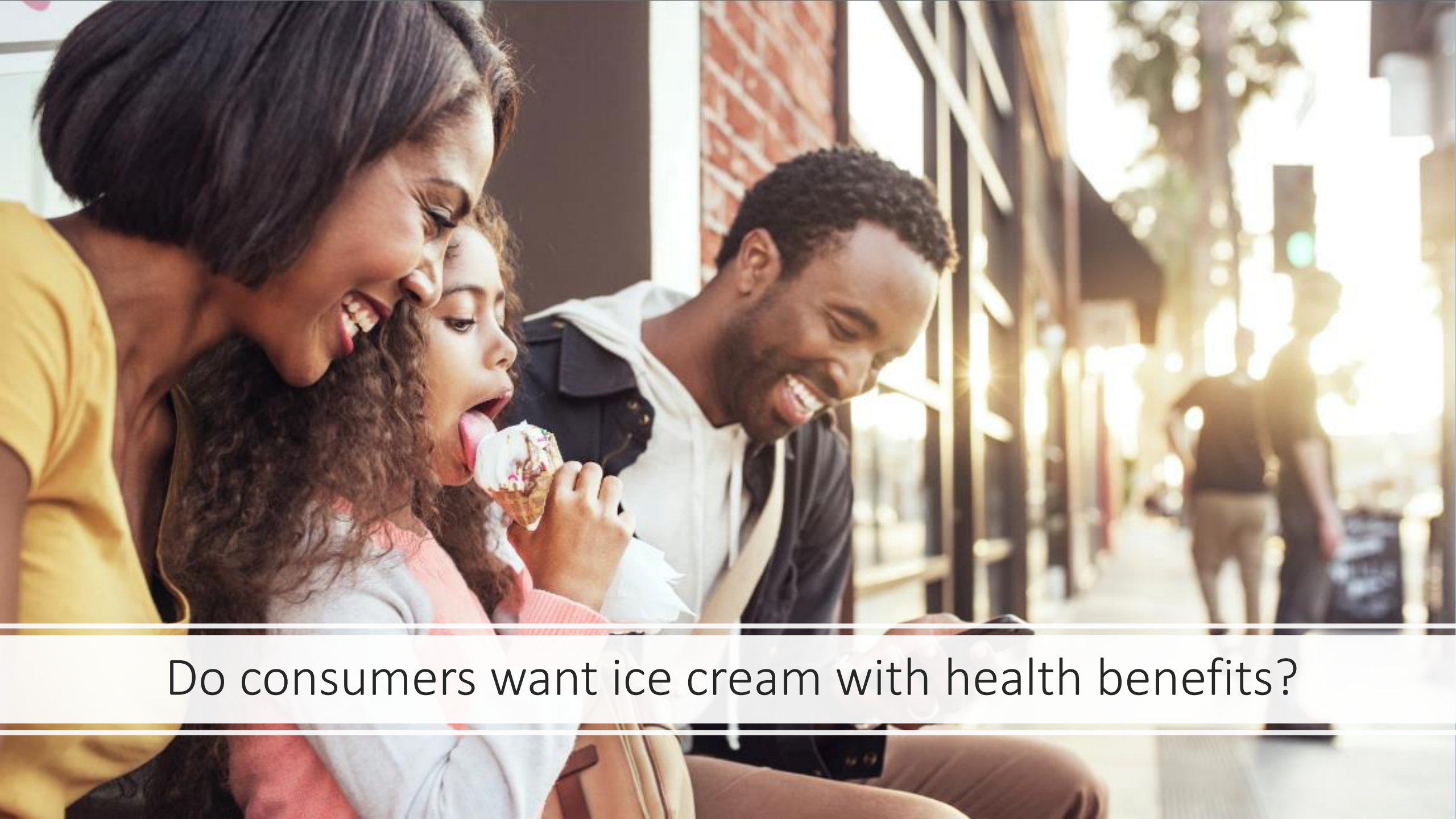
2015 wellmune

2017 BC30 PROBIOTIC

2020 Bio-K+ PLUS INTERNATIONAL INC.

2021 Sporevia PROBIOTIC, BIOSEARCH LIFE

2022 Natreon



Do consumers want ice cream with health benefits?

Consumer proactivity toward health drives demand for functional foods, beverages and supplements

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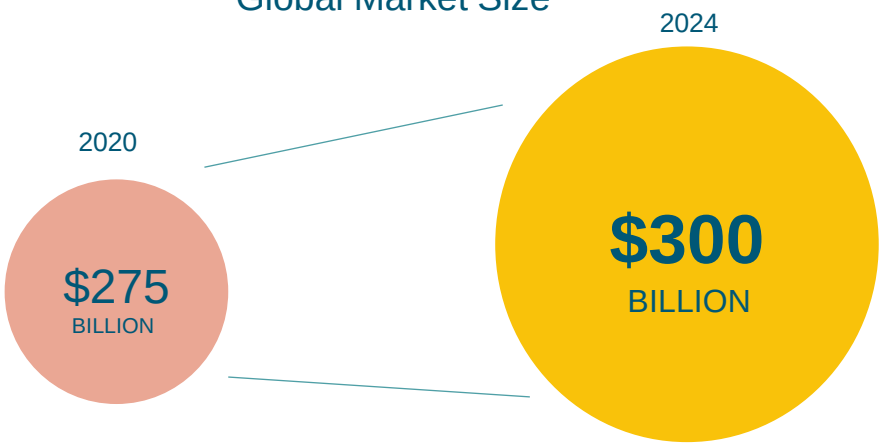
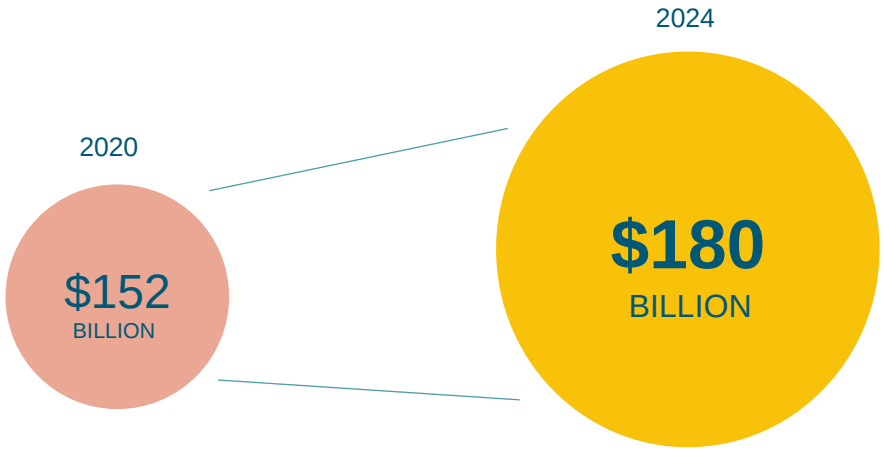
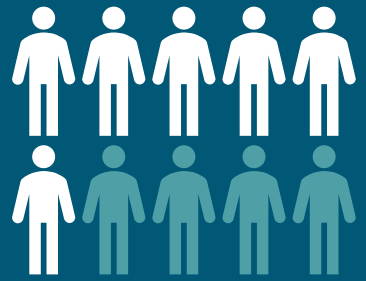
Functional Foods & Beverages Global Market Size



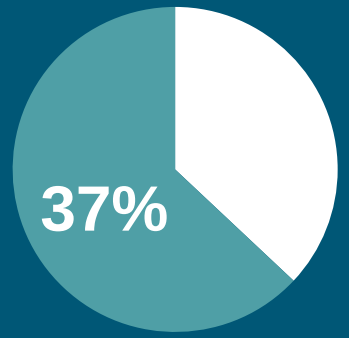
Dietary Supplements Global Market Size





6 in 10 consumers

proactively seek added functional benefits from their everyday foods & beverages[1]



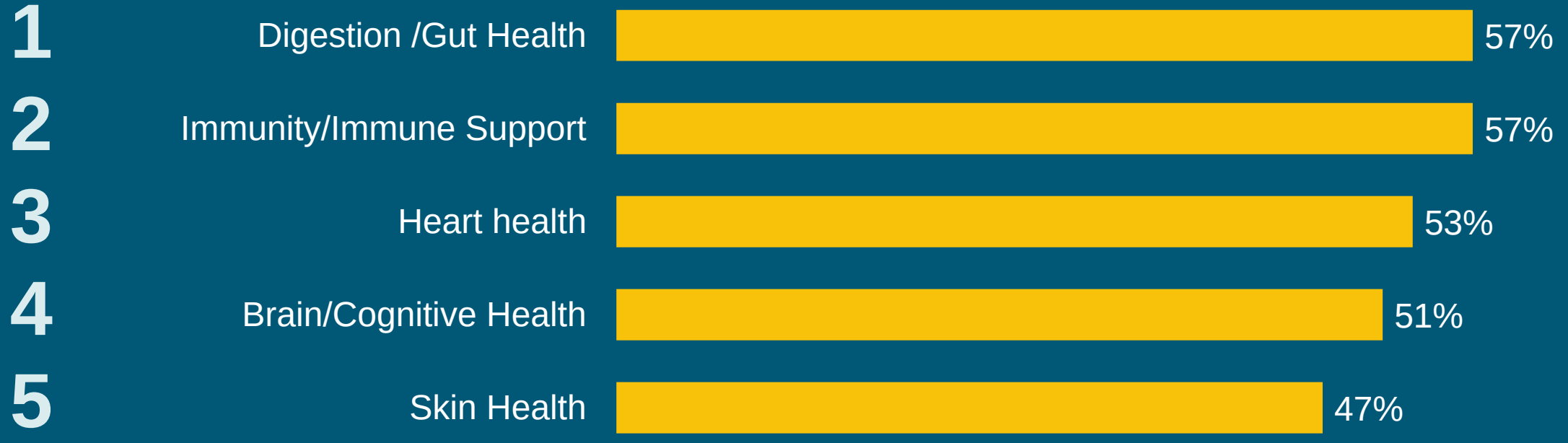
Are motivated to buy a healthy lifestyle product after seeing scientific data supporting its benefits[1]

11%

growth in annual launches of functional foods & beverages[2]

Source: [1]Kerry Proprietary Insights | [2]Direct comparison of 2015 new product launches to 2020 new product launches. (Innova)

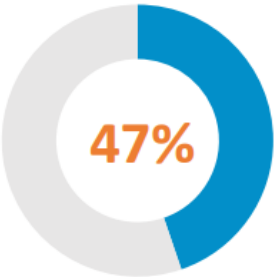
What health benefits are important to consumers?



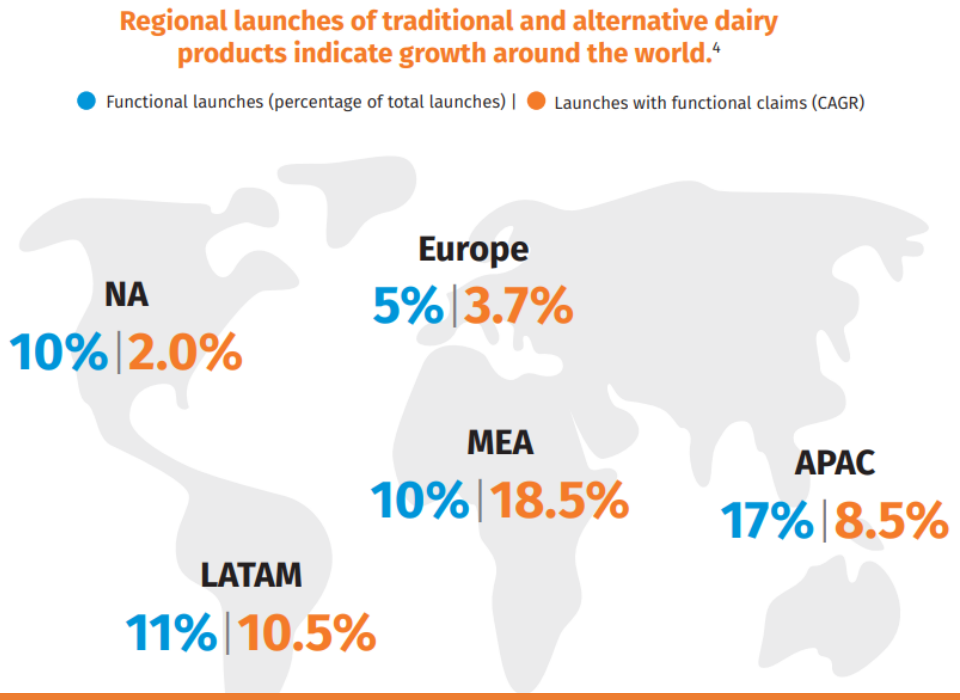
Source: Kerry Global Consumer Survey - 2023

Growing Desire & Willingness to Pay for Digestive Health Benefits

47% of consumers find food and drink that can improve digestive health appealing.



Food & beverage products launched with "probiotic" claim have grown **41%** in the past 3 years.

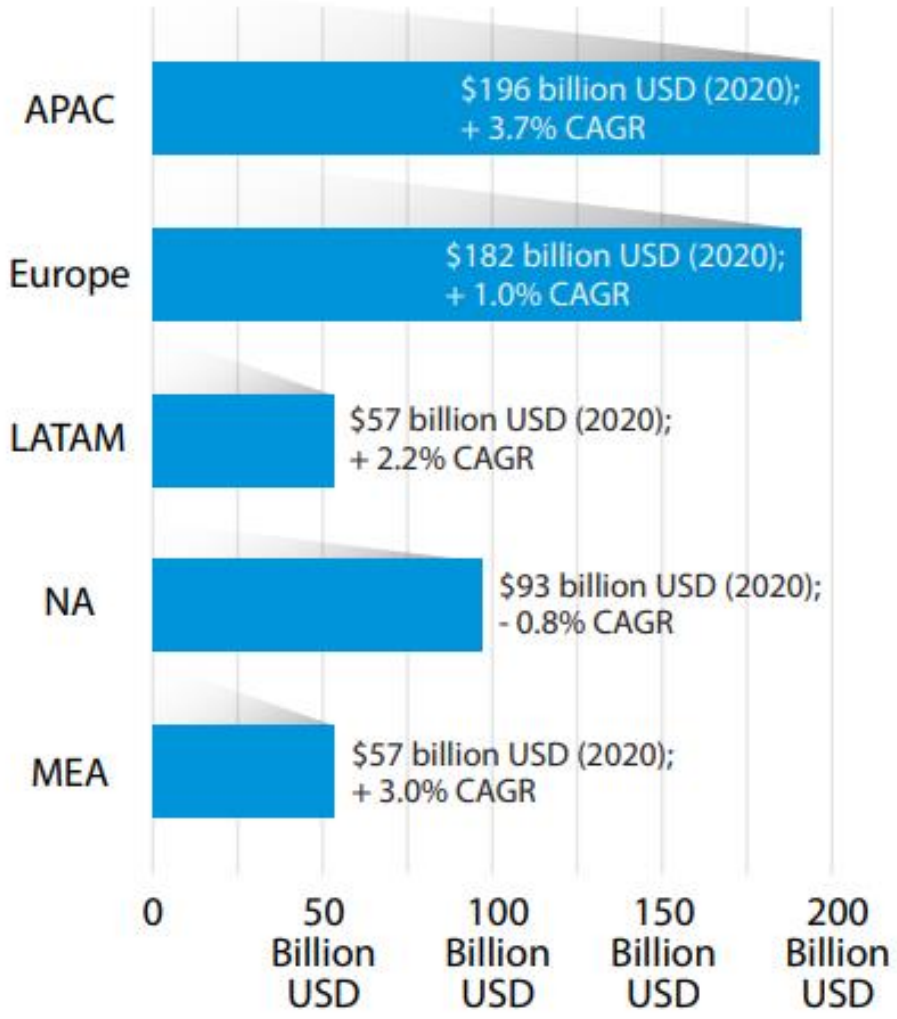


39% of consumers will pay a premium for digestive health related products!

Sources: FMCG Gurus and Opportunities Global Digestive Health , Mintel GNPD, Kerry SSI Consumer Survey

The global market for dairy and dairy alternatives is **growing, with an estimated 2021 market value of $585 billion USD.**[1]

Dairy and dairy alternatives market growth is much the same in individual regions:[2]



[2]Euromonitor Passport, August 2020

Ice cream sales remain large globally

- The U.S. frozen dessert market size was valued at USD 30.95 billion in 2021 and is expected to expand at a compound annual growth rate (CAGR) of 4.6% from 2022 to 2030. Increasing product launches in the frozen dessert segment such as custard, yogurt, gelato, granita, ice cream, and sherbet would further drive the market. .
- The increasing number of health-conscious consumers seeking out a low-carb and low sugar diet with nutritional benefits will bode well for the market growth. Manufacturers in response to the trend are introducing protein-rich frozen desserts with various health benefits.

Source: Grandviewresearch: U.S. Market CAGR, 2022-2030

Consumers look to ice cream as a premium, experimental, permissible indulgence

Permissible Indulgence

- Balancing indulgence with a health appeal. Low sugar, high protein content and low calories.
- Launches with probiotic benefits is small but has huge potential.
- Milk alternatives such as almond or coconut milk are trending.

Texture-based innovations

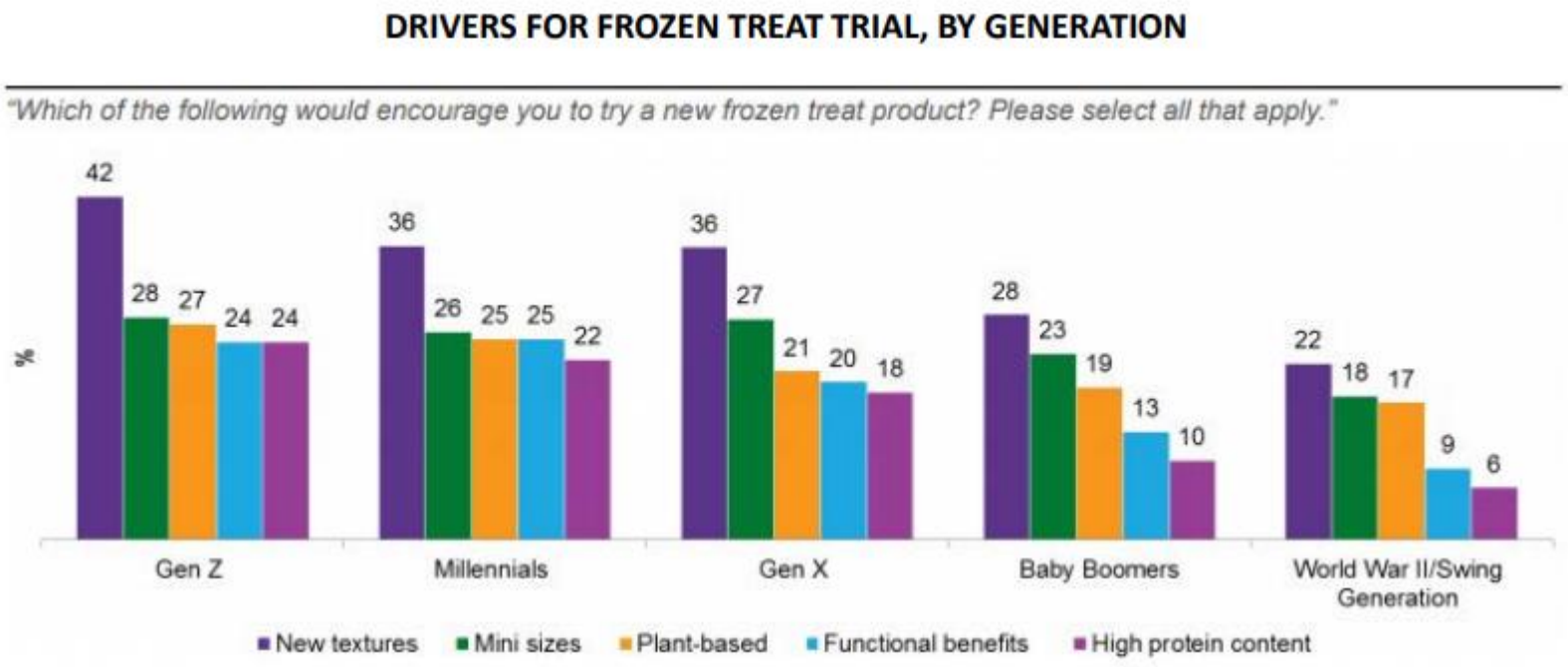
- Consumers want experiences that appeal to all senses.
- Inspiration can be found in Japan & South Korea with the use of items such as cake.

Snacks & Size Portions

- Ice cream is now looked at a snacking option any time of the day.
- When consumers choose to indulge, they prefer small-sized ice cream snacks.

Source: Euromonitor Ice Cream and Frozen Desserts in the US November 2017, Mintel Ice Cream 2018 Global Annual Review, Mintel A year of innovation in ice cream 2018.

New textures drive trial, but consumers also interested in frozen treats with functional benefits



20% of consumers would be encouraged to try a new frozen treat product if it had functional benefits, highlighting an opportunity for manufactures to deliver digestive health benefits to further promote consumption

Source: Lightspeed?Mintel

Category Evolution

- In the traditionally indulgent ice cream category, products with better nutrition attributes and added health benefits have taken over the market.

Growth of functional ice cream

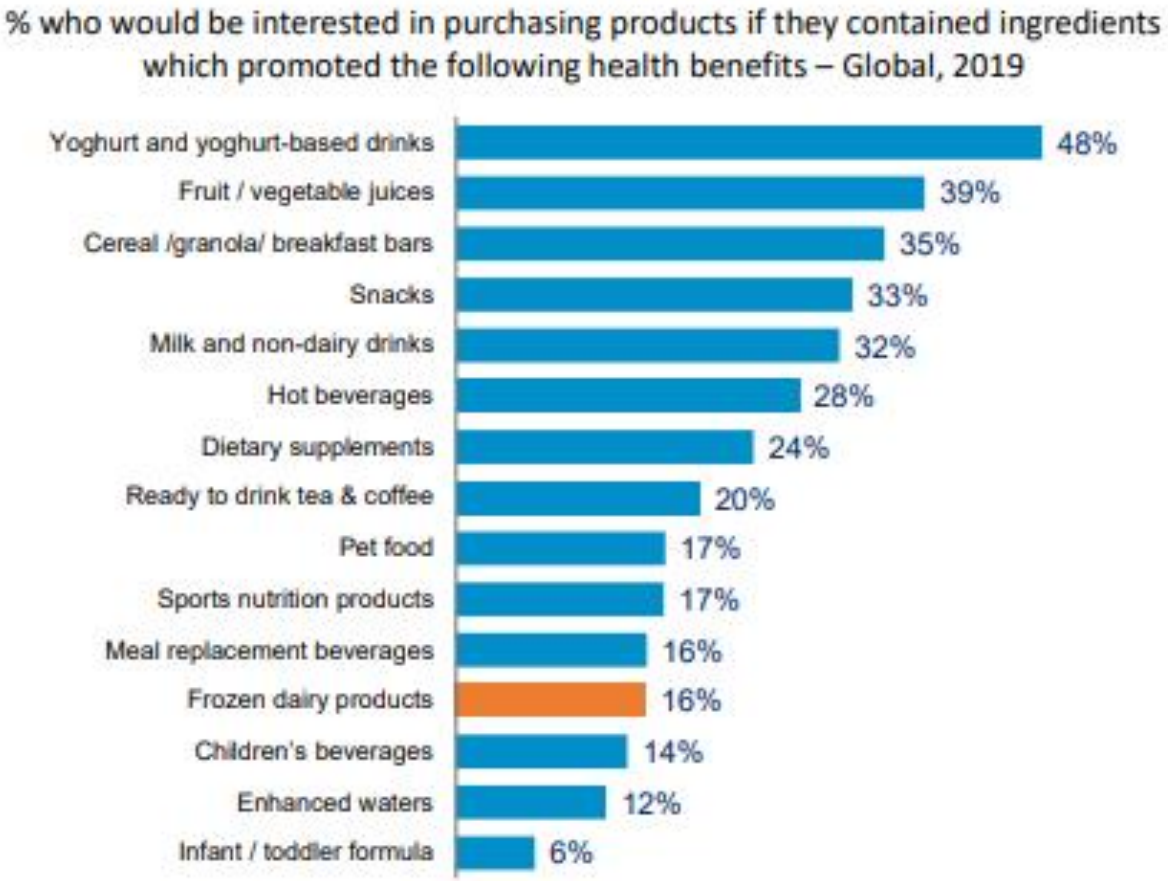
4.2%
of U.S. ice cream & frozen treat launches carried a functional claim in 2018 – vs. 1.5% globally.

28%
of the functional ice cream & frozen treat launches globally carried a digestive or probiotic claim in 2019 – a 100% increase over 2017.

Globally, launches of probiotic food & drinks have grown at **16% CAGR** from 2015-2019.

Source: Mintel GNPD

Roughly 1 in 6 consumers globally interested in purchasing frozen dairy products with digestive health benefits!



Source: Kerry Proprietart Consumer Survey-Digestive & Immune Health, 2019

Non-Dairy also offer innovation opportunity for probiotics

- Consistent with the growing interest in dairy alternatives across categories, plant-based and dairy-free varieties of ice cream and frozen desserts have grown significantly in recent years.

- As consumers move to avoid dairy for diverse reasons, fortification of non-dairy products with probiotics and added health benefits will add appeal.

17% adults in UK avoid dairy.

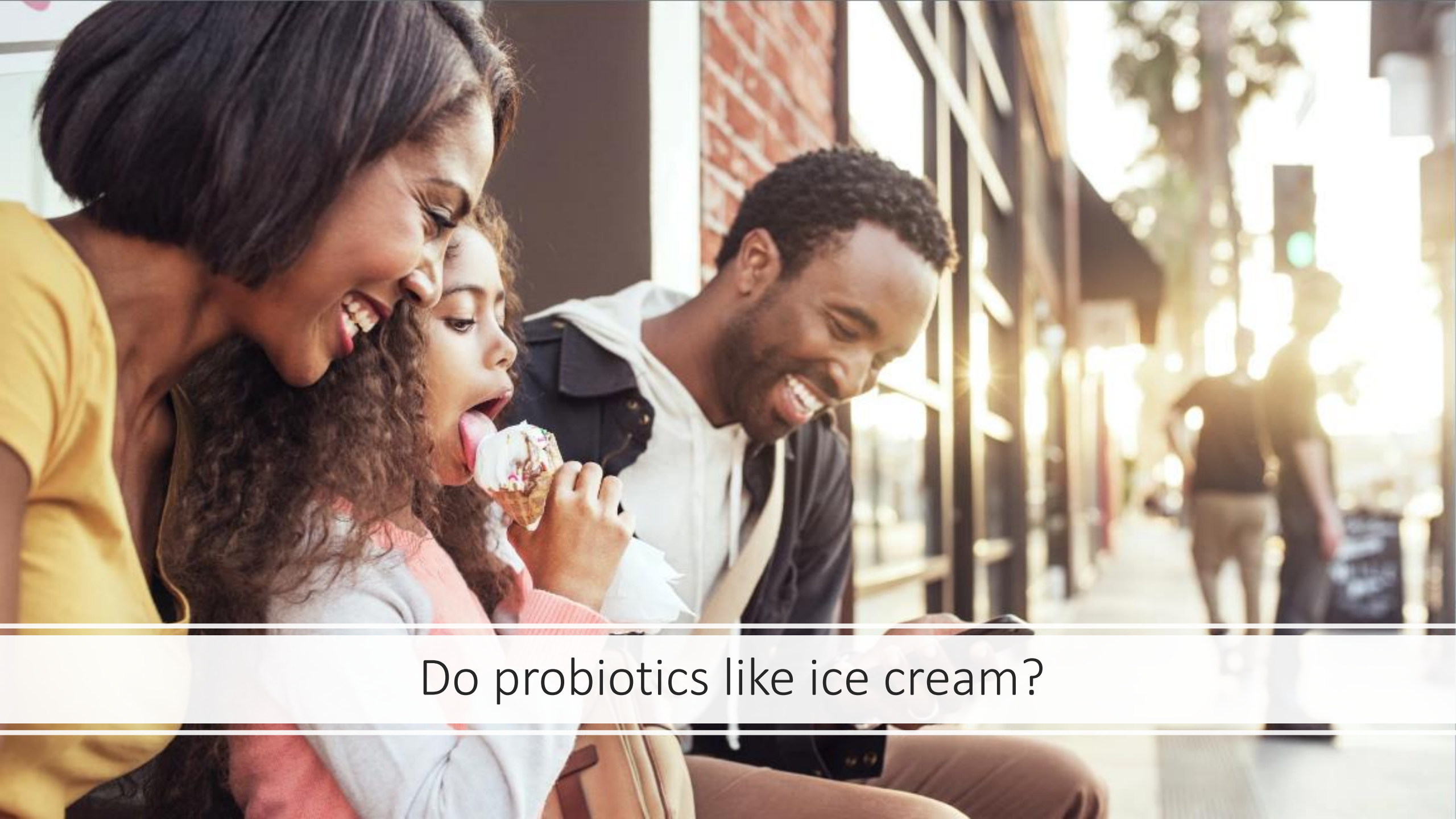
25% U.S. adults interested in dairy-free ice cream.

Source: Mintel, A year of innovation in plant-based drinks, yogurts & ice creams, 2019

Do consumers want ice cream with health benefits?

Yes!

- The Frozen Dessert market is robust, worth 30 Billion dollars
- **20% of consumers** would be encouraged to try a new frozen treat product if it had functional benefits, highlighting an opportunity for manufactures to deliver digestive health benefits to further promote consumption
- Roughly 1 in 6 consumers globally interested in purchasing frozen dairy products with digestive health benefits!



Do probiotics like ice cream?

PROBIOTICS
WHO ARE THEY AND THEIR IMPACT IN THE FOOD INDUSTRY

- The International Scientific Association for Probiotics and Prebiotics defines probiotics as "**live** microorganisms that, when administered in **adequate amounts**, confer a **health benefit** on the host[1]".
- Consumer's demand for health promoting food products is on the rise.
- Probiotics can enhance products value proposition with added health claims.

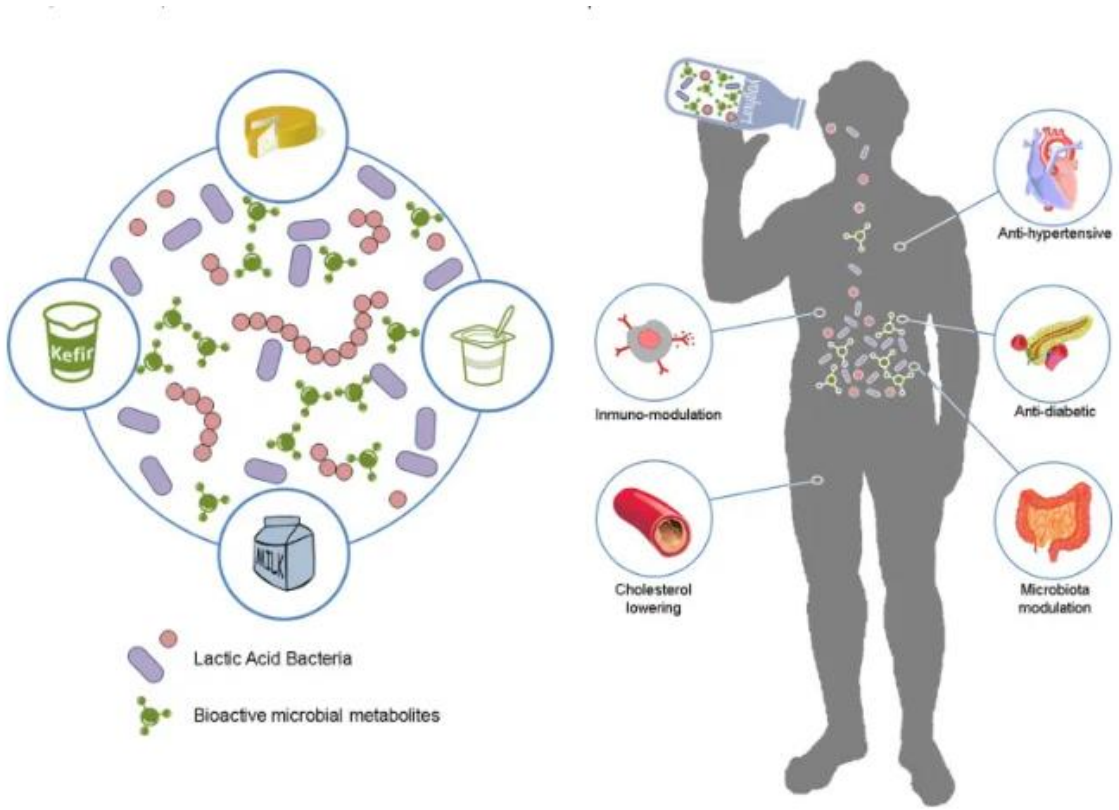
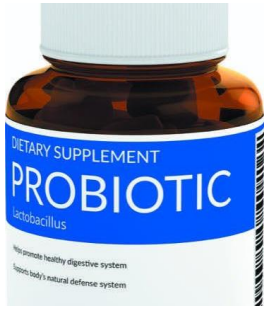
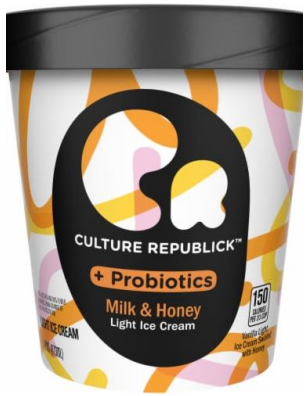


Image source: Linares *et. al.* 2017. Front Microbiol., 18:8:846.

[1]Hill C *et al*. 2014. Nat Rev Gastroenterol Hepatol., 11:506-14.

PROBIOTICS
Application in Food Matrixes



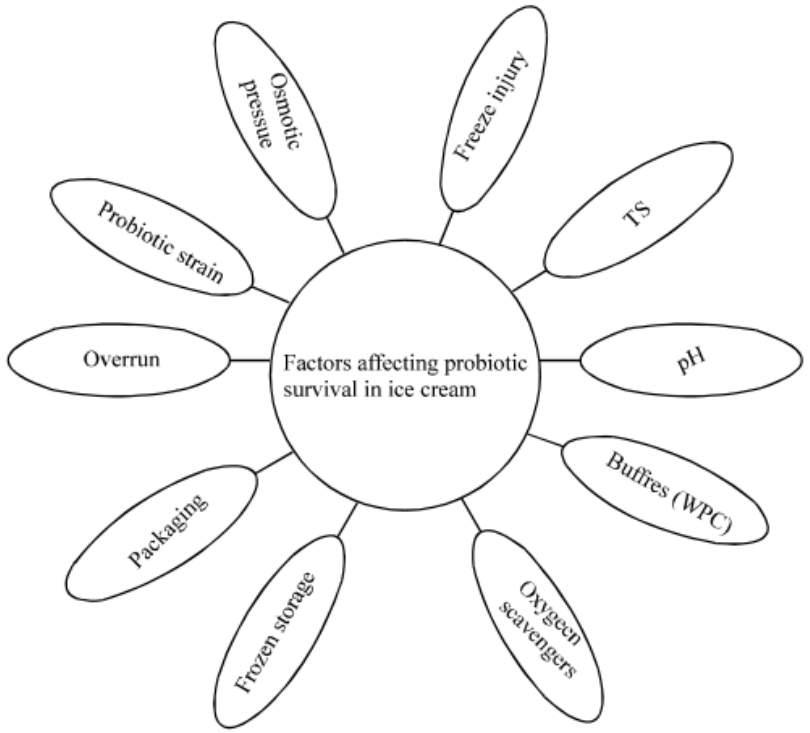


With each application comes different challenges for probiotics to overcome:

- Manufacture processes
- Storage conditions
- Interactions with other product ingredients
- Product intended way of use

Dairy Applications- Ice Cream

- Ice cream is an ideal vehicle for delivery of these organisms in the human diet!
- Among the frozen dairy products with probiotics, ice cream is great due to is near to seven pH, which helps probiotic bacteria survive better when compared to low pH applications.
- Storage conditions (cold temperatures) are beneficial to preserve bacterial viability.
- Ice cream provides an additional level of protection due to its high total solid content, including fat and milk proteins.
- Ice cream is a popular product by consumers, making it a good target for probiotic supplementation.



Source: Homayouni et al. 2012, International Journal of Dairy Science, 7(1): 1-10

Technological hurdles for probiotic incorporation in ice cream

In the case of frozen products like ice-cream, this implies overcoming intrinsic hurdles which take place in the processing of ice-creams, such as the beating step, where air is incorporated – known as overrun – and storage under freezing temperatures, which affects survival of the probiotic microorganisms during storage, and the way in which the bacterial inoculum is added to the product (Cruz *et. al.* 2009, Food Research International 42 1233-1239).

The addition of probiotics strains into a food matrix implies the need to assure the viability of the probiotic culture at high levels during the storage period, without altering its sensory characteristics (Stanton et al., 2003).

In addition, great attention should be given to the correct choice of the other ingredients to be used in the product, especially any fruit pulp/juice, which will give the final flavor to the product (Cruz *et. al.* 2009, Food Research International 42 1233-1239).

HURDLES

Overrun process

- Overrun is defined as the ice-cream percentage of volume increase in relation to the liquid mix used to make it and is related to the amount of air incorporated during the manufacturing process.
- Oxygen tolerance in probiotic bacteria is also strain-dependent and bifidobacteria strains are more susceptible than lactobacillus. Exposure to oxygen during manufacture and storage of dairy products is highly significant for probiotic bacteria.
- The selection of oxygen-resistant strains is essential to succeed in maintaining the viability of the culture in probiotic ice-creams, since the overrun operation cannot be eliminated from the processing procedure.
- High shear stress is also present during overrun

Cruz *et. al.* 2009, Food Research International 42 1233-1239.

Overrun process and its effect on probiotic survival

Ferraz et al. (2012) found that higher overrun levels negatively influenced cell viability, with a decreased of 2 log CFU/g for the 90% overrun treatment.

Table 2–Viable *L. acidophilus* counts (log CFU/g) throughout frozen storage (0 to 60 d) in probiotic ice creams subjected to different overrun levels.

Ice creams/d	0	1	15	30	60
P45	8.01^{aA}	8.06^{aA}	8.04^{aA}	8.04^{aA}	8.04^{aA}
P60	8.02^{aA}	8.10^{aA}	7.83^{bB}	7.40^{bC}	7.00^{bD}
P90	8.04^{aA}	8.02^{aA}	7.46^{cB}	7.09^{bC}	6.06^{cD}

$^{a–c}$Different lowercase letters in the same column represent statistically different results ($P < 0.05$). $^{A–D}$Different uppercase letters in the same line represent statistically different results ($P < 0.05$). P45, P60, P90 = see Table 1. Initial bacterial count in the mix prior to overrun was 8.06 log CFU/g.

Freezing & storage of ice cream and the impact on probiotics

- Freezing of the ice cream mixture can lead to serious damage to bacterial cells.
- Cells can be lethally injured by damage to their cell walls or rupture of their membranes caused by the ice formed in the external medium, or the cells may be ruptured by ice formed inside the cell and by concentration of solutes in the extracellular medium.
- During storage recrystallization, is a concern as well as lactose crystal formation.

Kozlowicz *et al.* 2019. Food Science and Technology 116 108562.

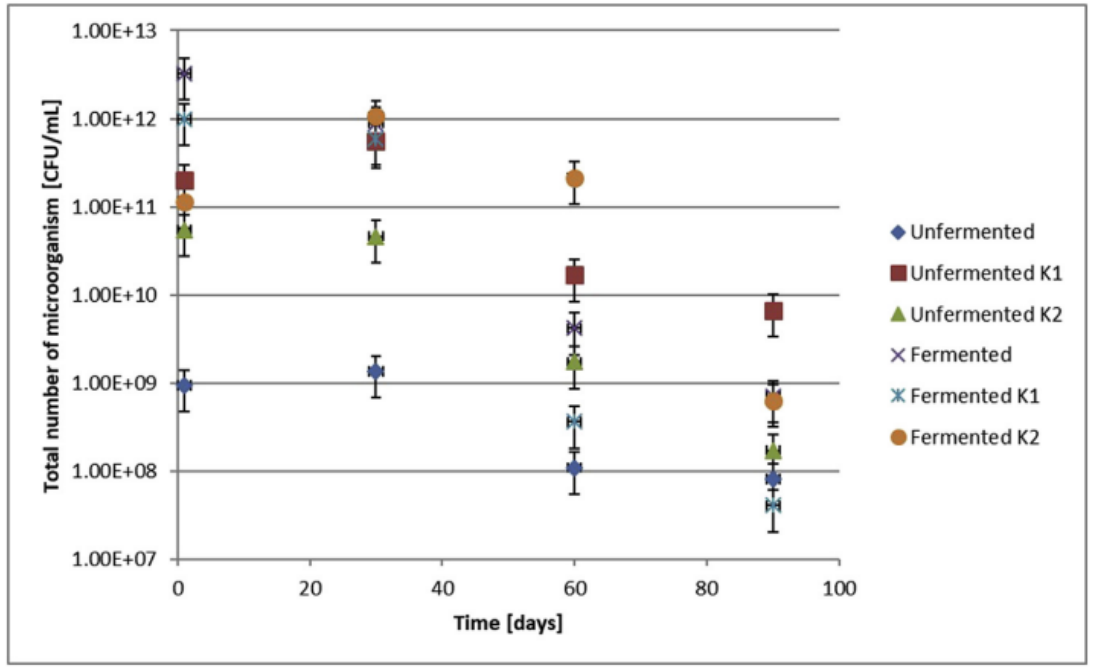


Fig. 2. Survival of *Lactobacillus rhamnosus* B 442 in ice cream during storage.

Kozlowicz *et al.* (2019). Found that microbial load decrease over time , however, unfermented ice cream was affected less by storage.

Leandro *et al.* (2012). Found that Lactobacillus counts remained stable shortly after processing and for up to 40 days postproduction.

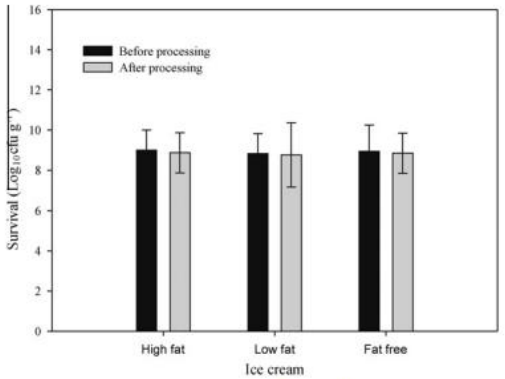


Fig. 1 – Counts of *Lactobacillus delbrueckii* UFV H2b20 strain in mixes and ice creams newly produced. All experiments were performed in duplicate and replicate at least three times.

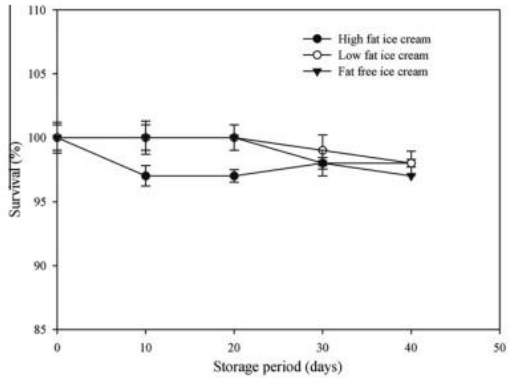


Fig. 2 – Survival rate of *Lactobacillus delbrueckii* UFVH2b20 in ice cream samples after 40 days of storage at −16 °C. All experiments were performed in duplicate and replicate at least three times.

HURDLES

Ingredient Interactions

Fruits, in the form of juice or pulp, are widely used as flavorings in ice-creams, being commercially available in the form of pasteurized juices or frozen pulps, representing the most well-known source of flavor for this product.

Certain fruits, like passion fruit, may inhibit probiotic microorganisms, resulting in loss of viability in the product, due the presence of intrinsic factors linked to their composition

Interactions of probiotics with emulsifiers, hydrocolloids, sweeteners, fat content should be considered.

Cruz *et. al.* 2009, Food Research International 42 1233-1239.

HURDLES

Ingredient Interactions

- The addition of passion fruit juice or pulp was not appropriated to produce refrigerated mousses supplemented with *L. acidophilus* and stored at 4ºC.
- The addition of passion fruit or guava did not affect the viability of *Lactobacillus acidophilus* in frozen mousses, which presented high populations of probiotic until the end of storage.
- Consequently, freezing of samples was suitable to preserve the viability of *Lactobacillus acidophilus* and to enlarge shelf life of mousses

Table 1. Values of pH and population of *Lactobacillus acidophilus* obtained for the different mousse trials studied.

Mousse trial	Storage temperature	Storage days	pH	*L. acidophilus* (log cfu.g^{-1})
M1 (PJ)	4ºC	1	5.00	7.28
		21	4.94±0.02	4.09±0.36
M2 (PJ+I)	4ºC	1	4.98±0.02	6.51
		21	4.98	1.78
	-18ºC	1	5.00	6.74
		21	5.03	6.57
		69	5.03	6.35
M3 (PP)	4ºC	1	4.99	6.64
		21	5.00	2.45
M4 (GP)	4ºC	1	6.05	7.09
		21	6.05	6.94
M5 (GP+L)	4ºC	1	4.93±0.01	7.36±0.07
		21	4.93±0.02	6.34±0.15
	-18ºC	1	4.91±0.01	7.25±0.02
		7	5.01±0.01	7.43±0.03
		56	5.06±0.01	7.29±0.06

M1 (PJ) = concentrated passion fruit juice; M2 (PJ+I) = concentrated passion fruit juice + inulin; M3 (PP) = pasteurized and frozen passion fruit pulp; M4 (GP) = pasteurized and frozen guava pulp; M5 (GP+L) = pasteurized and frozen guava pulp + lactic acid. Except for M2, containing inulin instead, mousses were produced with whole milk cream.

Buriti *et al.* 2007.Brazilian Journal of Microbiology, 38:315-317

Fat content and probiotic stability

Table 2 – Effects of pH on the survival for Lactobacillus delbrueckii UFV H2b20.

Ice cream	Viable counts	($log_{10}CFU.g^{-1}$)[a]	
	0 h* pH 7.0	3 h pH 3.0	pH 7.0
High fat	8.74 ± 0.06	8.80 ± 0.12	8.81 ± 0.08
Low fat	8.70 ± 0.17	8.80 ± 0.01	8.77 ± 0.12
Fat free	8.72 ± 0.19	8.90 ± 0.10	8.83 ± 0.16

* Cells counts after 30 storage days at – 16 °C.
[a] Each value in the table represents the mean value ± standard deviation (SD) from three trials.

Table 3 – Effects of bile salt on the growth of Lactobacillus delbrueckii UFV H2b20.

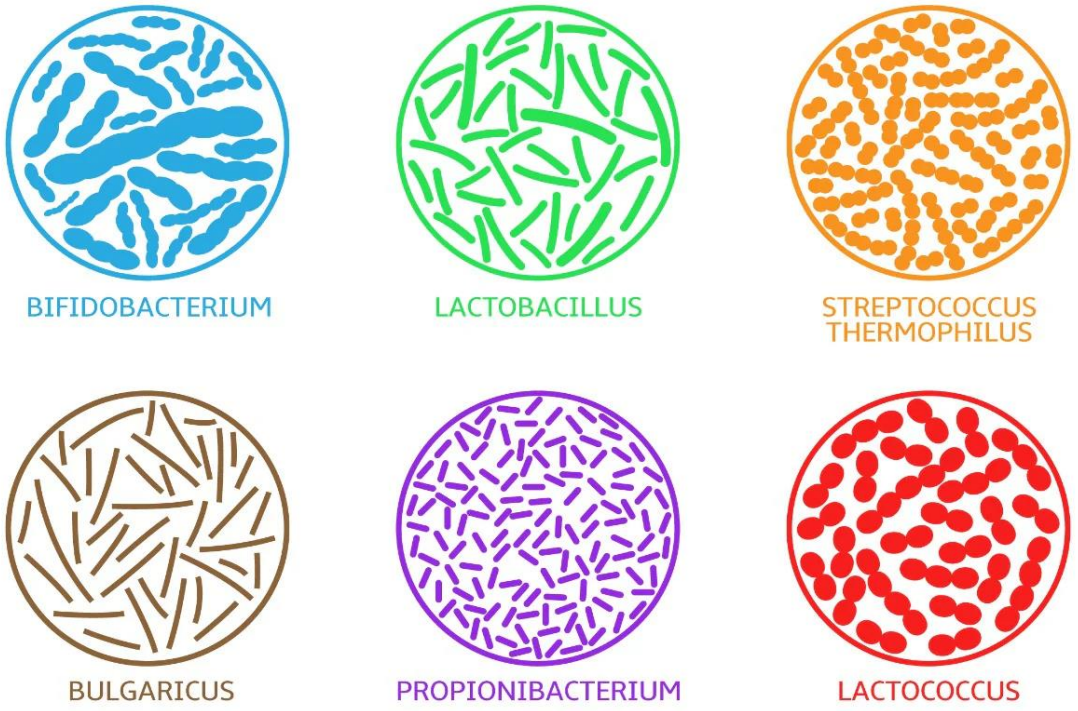
Ice cream	Viable counts	(log_{10} $CFU.g^{-1}$)[a]	
	Viable counts after acid (pH 3.0) treatment	Counts after 12 h incubation	
		Without bile salt	With bile salt (0.3%)
High fat	8.80 ± 0.12	9.36 ± 0.04	9.09 + 0.01
Low fat	8.80 ± 0.01	9.45 ± 0.11	9.13 + 0.00
Fat free	8.90 ± 0.10	9.36 ± 0.06	9.14 + 0.02

[a] Each value in the table represents the mean value ± standard deviation (SD) from three trials.

Leandro et al. 2012. 2013. Journal of Funtional Food. 5 503-507.

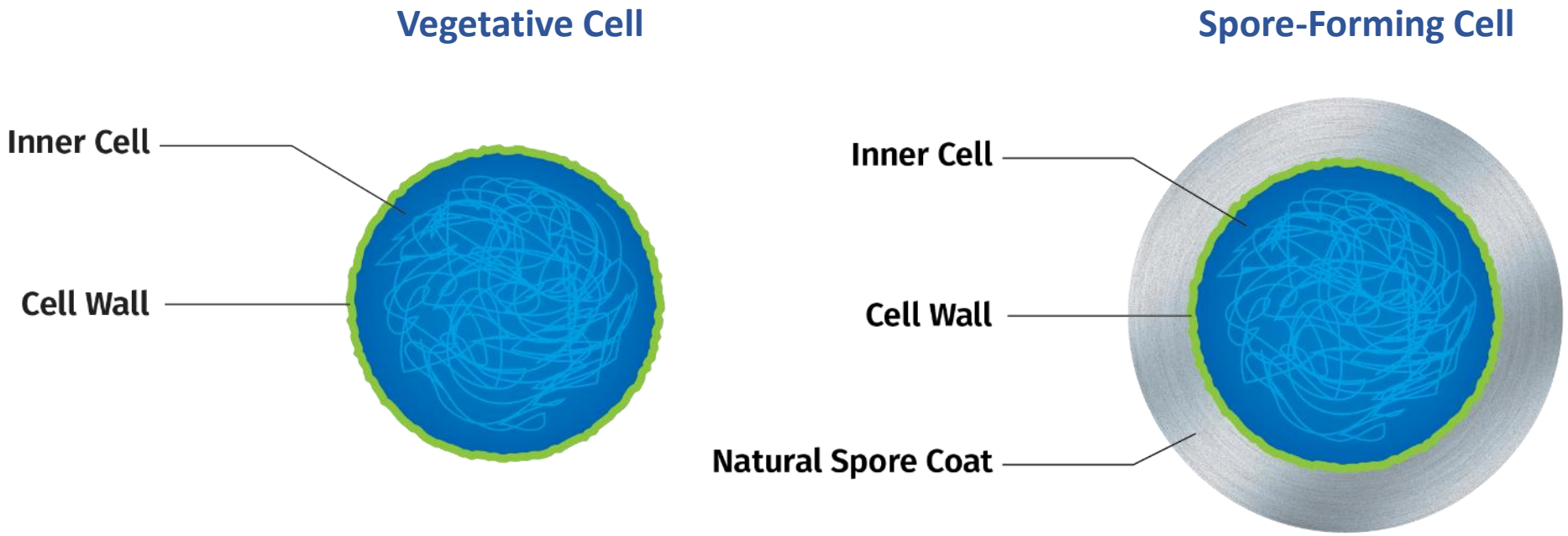
STRAIN SELECTION IS KEY

- **Will it survive manufacturing and shelf-life requirements of your product?**
- Is the **inclusion amount supported** by published, peer-reviewed clinical studies?
- Is there published data on the **benefits and safety** of the specific strain?
- Is it approved for use in multiple markets? (i.e., FDA GRAS / QPS)
- Will it **survive transit** through the gastrointestinal tract in efficacious quantities?



Forms of bacterial probiotics

While common vegetative probiotics strains are fragile, spore-forming strains like *Bacillus coagulans* can survive most manufacturing processes, allowing for innovation beyond the dairy case.



BC30 differentiated value for ice cream

It is a highly stable probiotic that provides superior survivability in typical ice cream manufacturing processes:

- Freezing
- Shipping & storage
- Shelf life
- Journey to digestive system

Vegetative probiotics such as lactobacillus and bifidobacterium are more susceptible to hurdles during ice cream manufacturing, unlike spore forming probiotics.

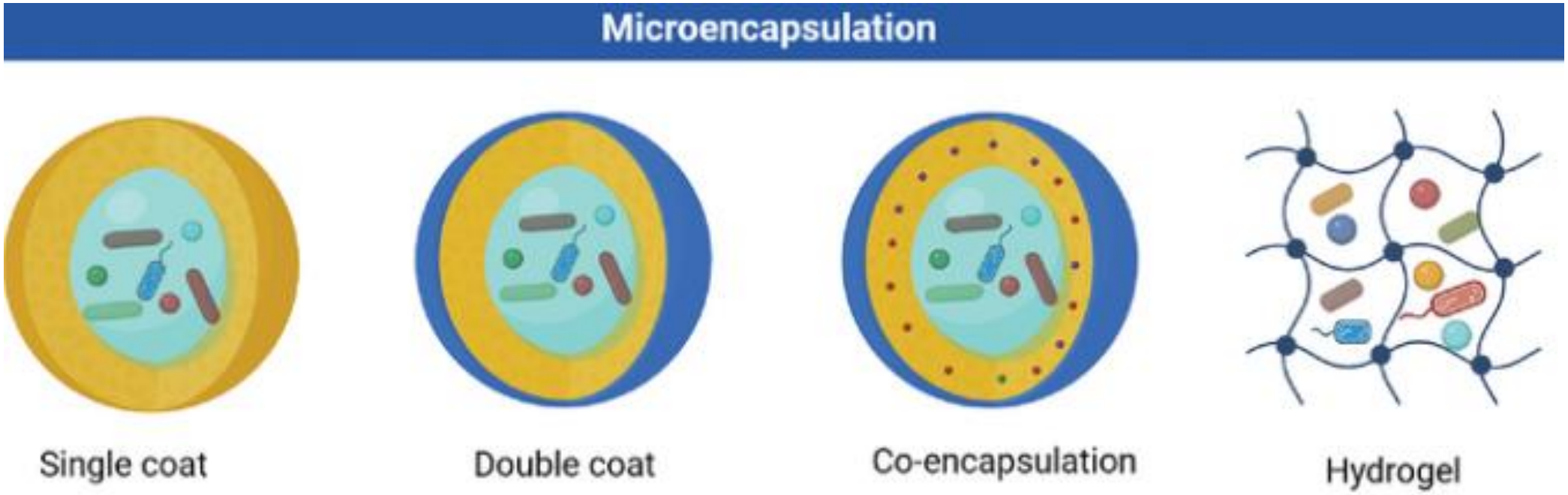
Example Survivability of GanedenBC^{30} in Ice Cream

Cell Count	Survival
500M CFU	119%
1B CFU	96.7%

Ice Cream Innovations with Ganeden**BC**^{30}

Microencapsulation to improve probiotic stability

- Microencapsulation refers to physicochemical processes that entrap an active compound or cell in a material to improve its functionality. The most investigated purpose for the microencapsulation of probiotic cells is to protect against gastrointestinal conditions.
- However, the effect of the food matrix and processing conditions on the survivability of microencapsulated probiotic cells should not be neglected. Indeed, the shelf life of a probiotic food is mainly based on the dropping kinetics of the alive probiotic population in the food product.



Sbehat et al. 2022. Microorganims. 10(10):1948.

Microencapsulation of probiotics in ice cream

- Afzaal et al. (2019) investigated the effect of encapsulation on the stability of *L. acidophilus* ATTC-4356 when inoculated in ice cream.

- He studied **Alginate- and Carrageenan**-encapsulated probiotic cells.

- Immediately after shock freezing, a high death rate was reported in encapsulated *L. acidophilus* because of cell damage that related to the formation of ice crystals, but it was still lower than that reported for free cells.

- However, this loss of encapsulated cells declined during storage. Specifically, the viable count of alginate- and carrageenan-encapsulated probiotics **decreased from 9.9 and 9.8 log CFU/mL at 0 day to reach almost 8.9 and 8.5 log CFU/mL after 120 days of storage,** respectively.

- Unpleasantly, the sensorial characteristics of ice cream were significantly affected.

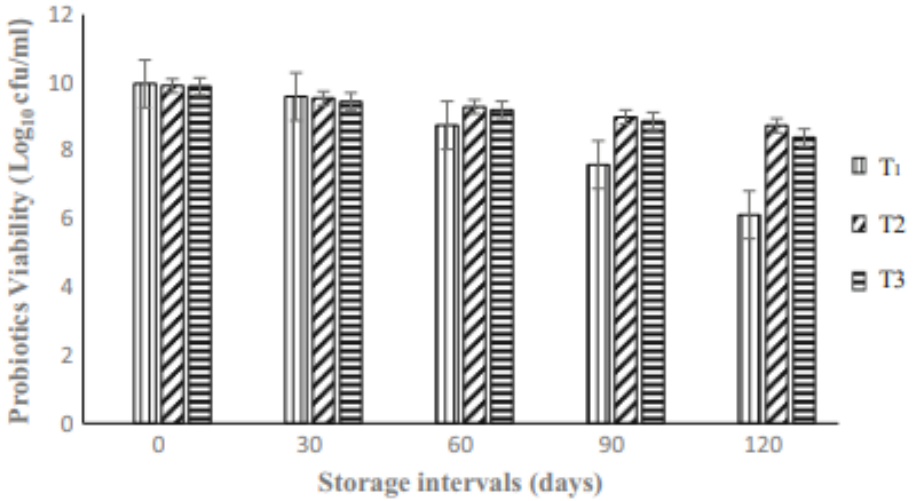


Fig. 1 Viability (Log_{10}cfu/ml) of free (non-encapsulated) and encapsulated (with sodium alginate and carrageenan) probiotic bacteria (*L. acidophilus*) in ice cream during storage intervals (0, 30, 60, 90, and 120 days). Each bar represents a mean value for the viability of probiotics. T1 (free/non-encapsulated cells), T2 (probiotics encapsulated with sodium alginate), and T3 (probiotics encapsulated with carrageenan)

So, do probiotics like ice cream? Yes, they do!

Ice cream is a good matrix for incorporation of probiotics

- Manufacturing process is friendly to microorganisms.
- Spore forming probiotics have already been successfully added to ice cream.
- Robust market indicates good acceptance by consumers.

Market trends

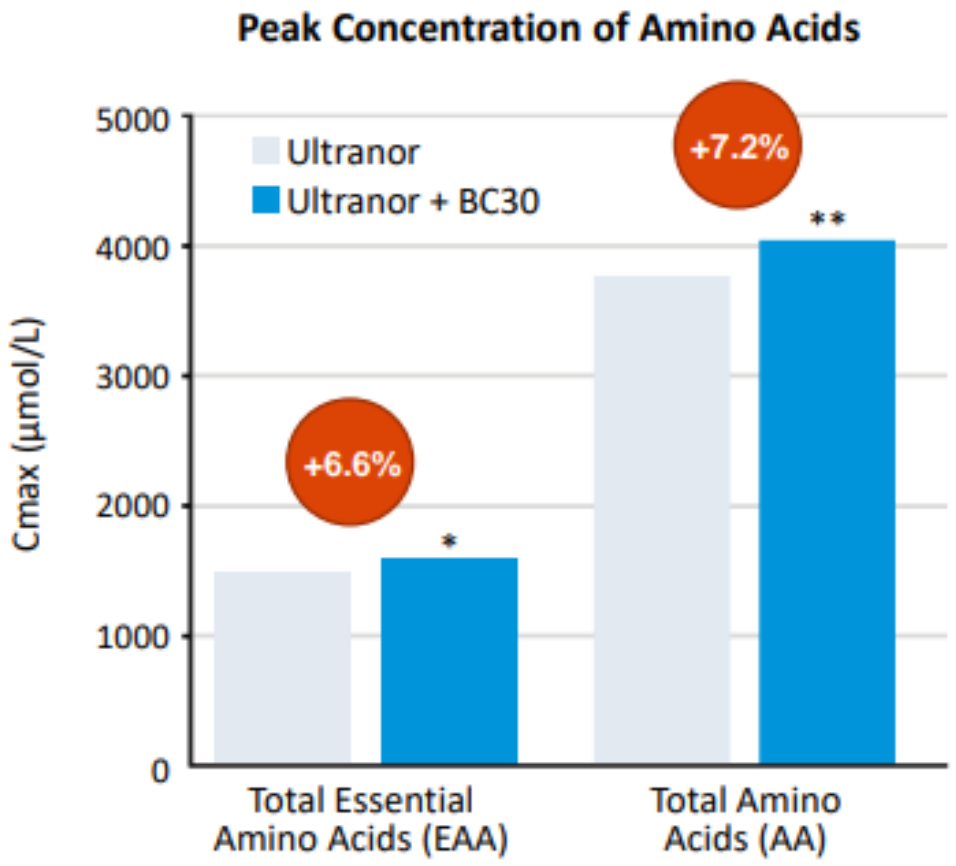
- GLP-1 as drug for weight lost, tread to ice cream market/snacks?
  - Probiotics can help with GLP-1 side effects and food containing probiotics can win in the market.
  - Ice cream with high protein content can increase claim substance with probiotics that can help protein absorption.
- Keto diets (low carb, high fat)
- Sugar reductions
- Sustainability & Environmental Impact

Clinical study evaluating BC30™ and impact on **milk** protein digestion

Conclusion: BC30 improves milk protein absorption in humans

Study Protocol

Study Site	Exercise and Performance Nutrition Laboratory, School of Health Sciences Lindenwood University, St. Charles Missouri
Population	30 healthy males and females
Age	18-55 years, average 26.4
Design	Double-blind, randomized, controlled, crossover study
Duration	7 weeks total; 2 weeks supplementation, 3 weeks washout, 2 weeks supplementation
Serving	1 billion CFU BC30 + 25g of Ultranor MPC (milk protein concentrate) daily



Clinical study evaluating BC30™ and impact on **plant** protein digestion

Conclusion: BC30 improves plant protein absorption in humans

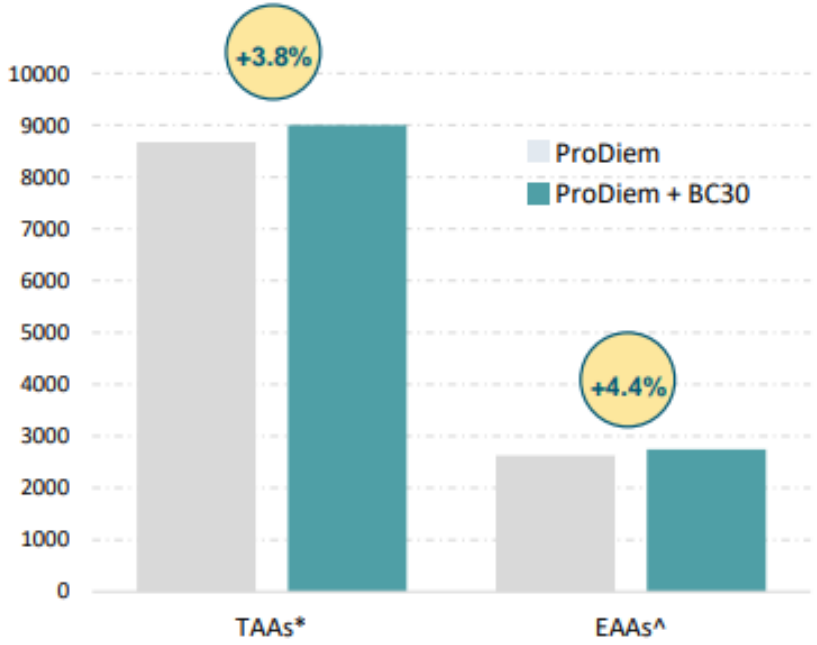
Study Protocol

Study Site	Exercise and Performance Nutrition Laboratory, School of Health Sciences Lindenwood University, St. Charles Missouri
Population	30 healthy older females
Age	50-70 years, average 63.5
Design	Double-blind, randomized, controlled, crossover study
Duration	7 weeks total; 2 weeks supplementation, 3 weeks washout, 2 weeks supplementation
Serving	1 billion CFU BC30 + 27g of ProDiem™ Complete PR (pea + rice protein concentrate) daily (=20g protein)

Results

Consuming BC30 **significantly* increased the total amino acids (TAAs)** absorbed into the blood.

Consuming BC30 tended^ to increase the total amount of essential amino acids (EAAs) and branched chain amino acids (BCAAs) absorbed into the blood.



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