The potential use of synbiotic combinations in cereal-based solid food products- A review

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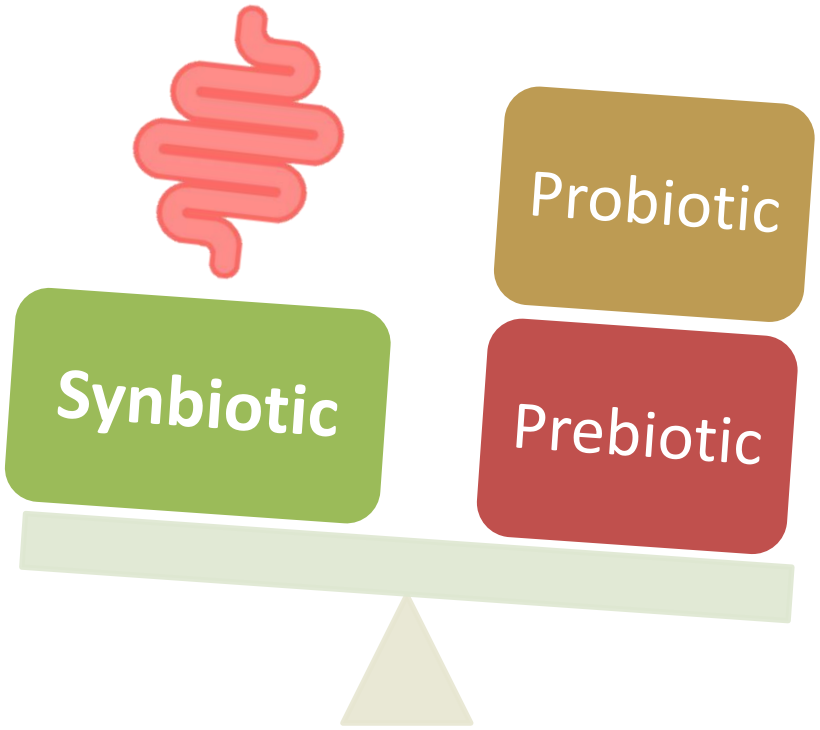
Introduction

SYNbiotic

- "A mixture comprising live microorganisms and substrate(s) selectively utilized by host microorganisms that confers a health benefit on the host" (Swanson, 2020).



Introduction

SYNbiotic

Complementary synbiotic

- Probiotic(s) + prebiotic(s) working to achieve one or more health benefits
- Comprises a probiotic plus a prebiotic (more than one of each can be used), working independently to achieve one or more health benefits.
- Probiotic and prebiotic components of the complementary synbiotic must meet the minimum criteria.
- Must be tested in the target host demonstrating a health benefit
- Do not need to also demonstrate selective utilization as this has been previously demonstrated by the prebiotic

Synergistic synbiotic

- Substrate selected to specifically enhance the health benefit delivered by the co-administered live microorganism
- Composed of a live microorganism and a selectively utilized substrate but neither needs to meet the minimum criteria stipulated previously for probiotics and prebiotics. Instead, these components are designed to work together, with the substrate being selectively utilized by the co- administered microorganism.
- Must be tested in the target host
- Must demonstrate both selective utilization and a health benefit
- On its own, the live microorganism need not meet the criteria of a probiotic
- On its own, the substrate need not meet the criteria of a prebiotic

Introduction

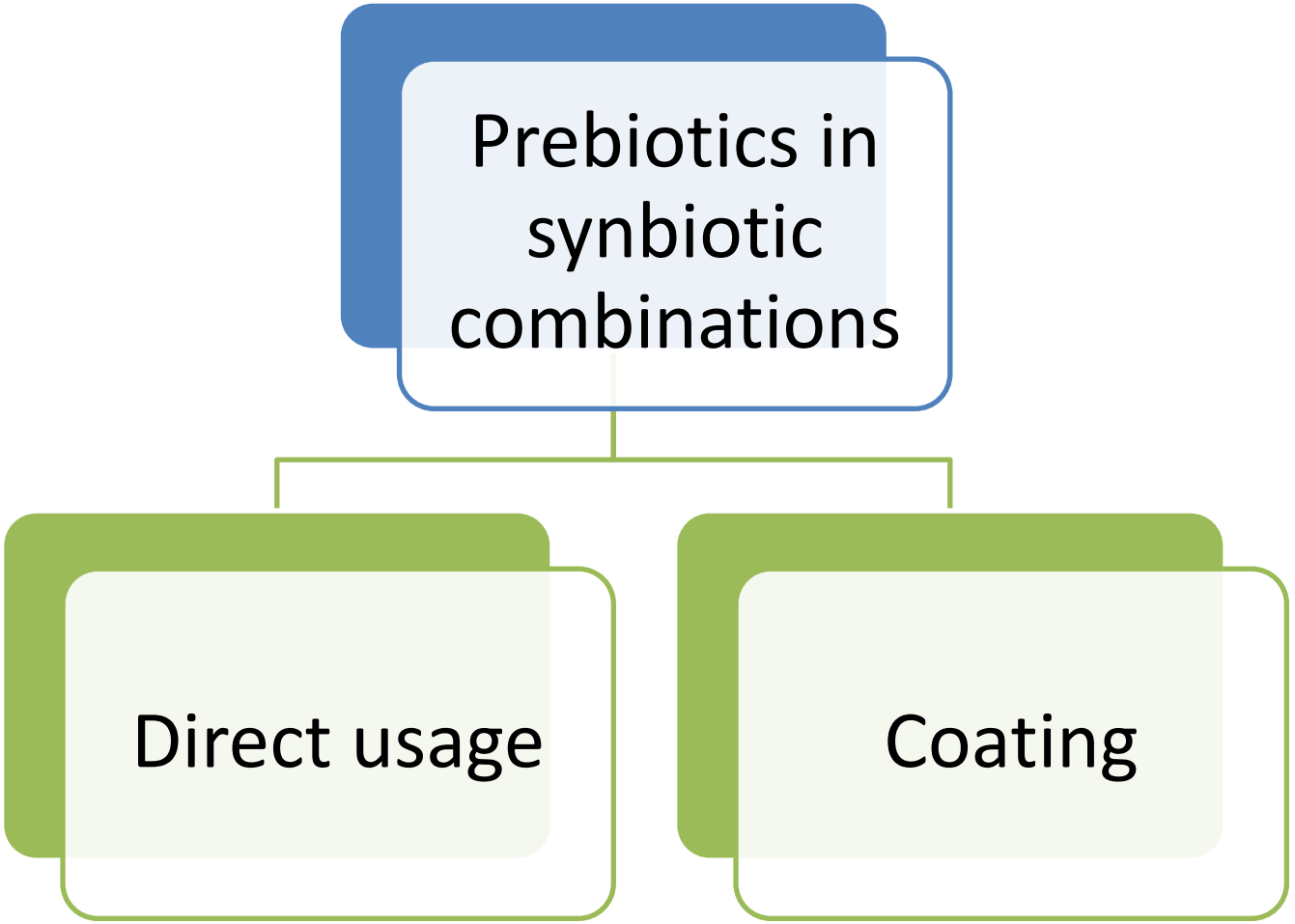


Fig. 4. The potential usage of prebiotics in 'synbiotic' combinations in solid cereal-based foods

Introduction

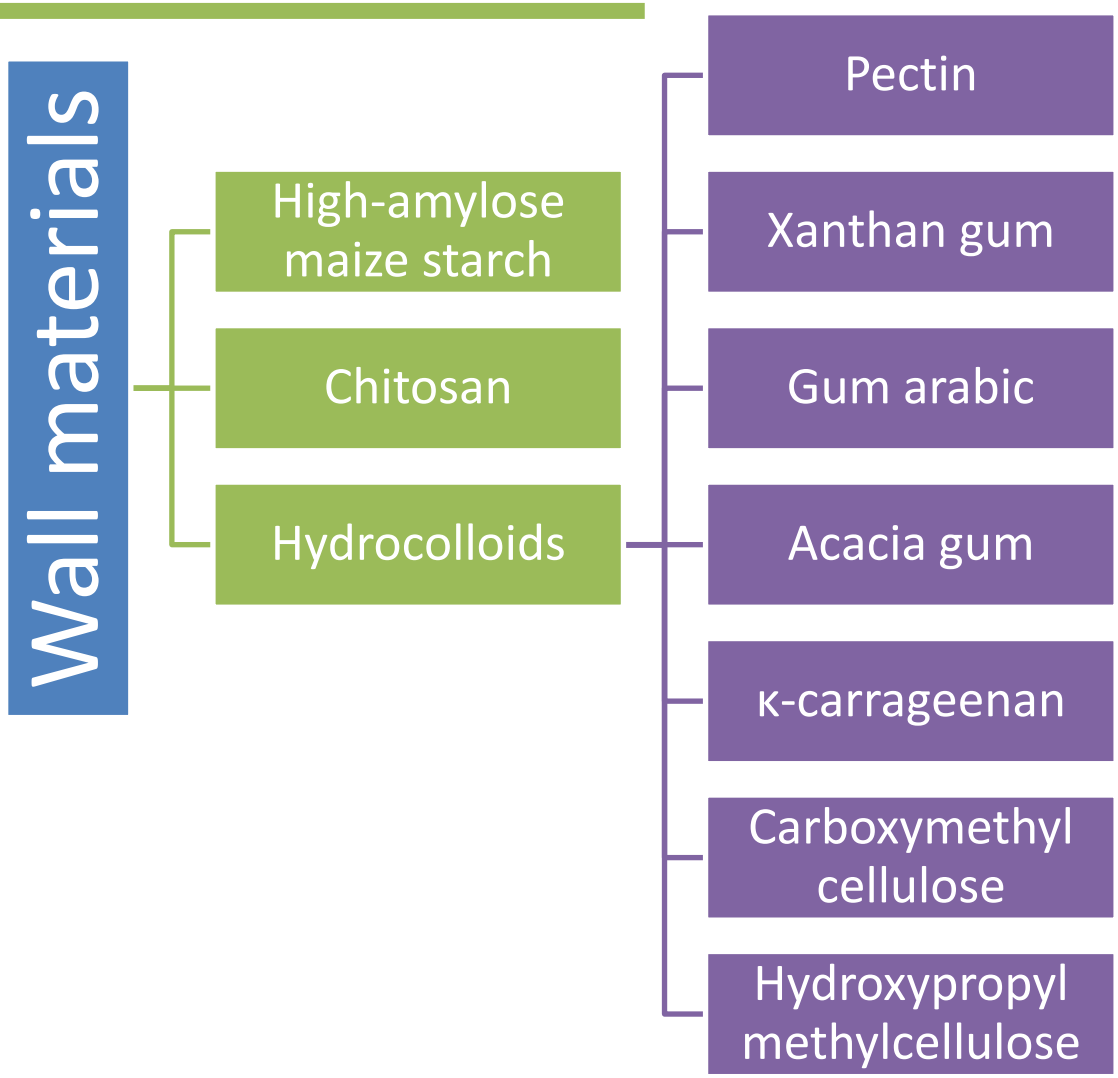


Fig. 6. The major potential prebiotics used of 'synbiotic' combinations in solid cereal-based foods

Introduction

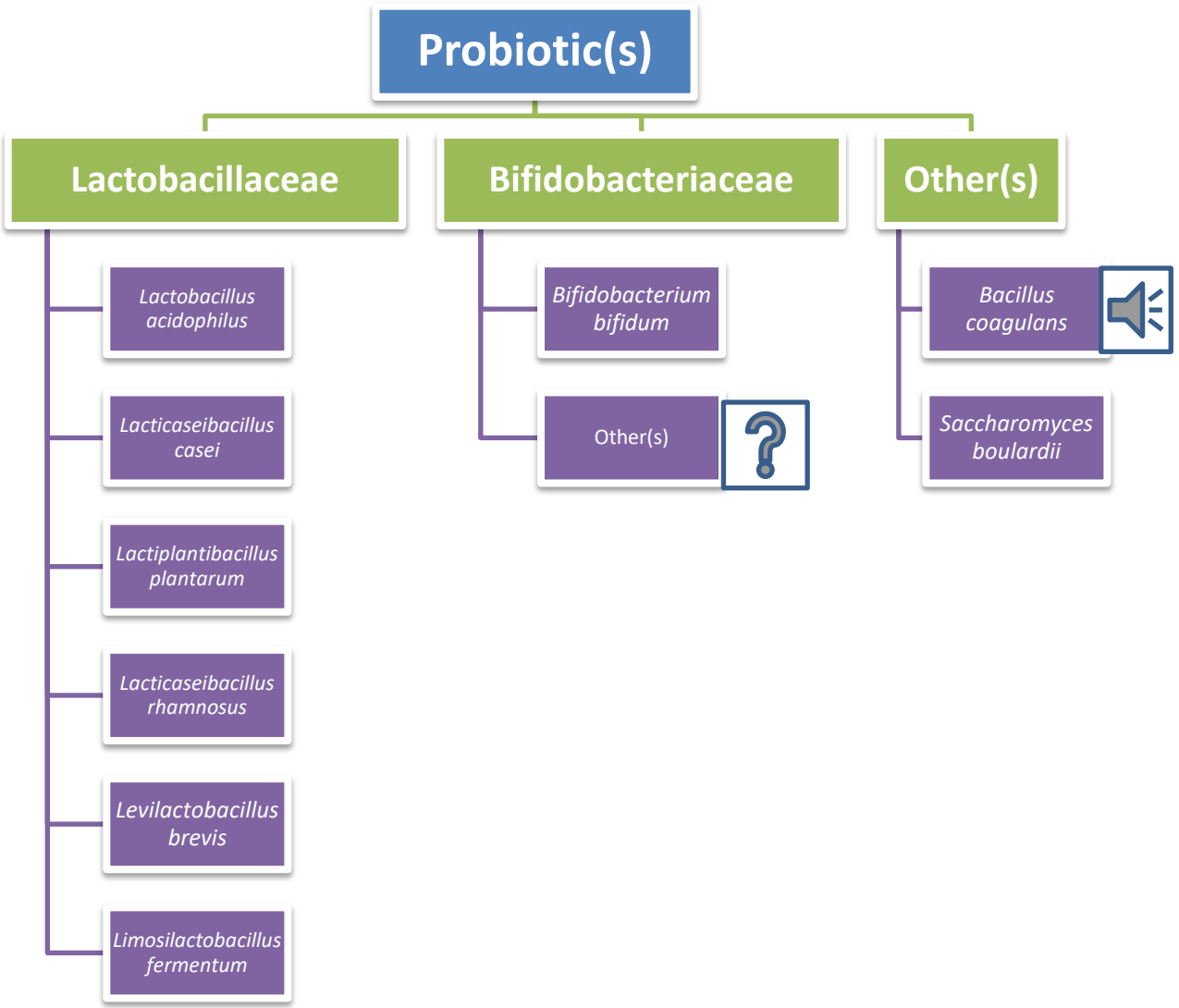


Fig. 5. The major probiotics used of 'synbiotic' combinations in solid cereal-based food products

Cake

Table 1. The potential use of synbiotic combinations in cakes

Product	Probiotic source(s)	Prebiotic or potential prebiotic source(s)	References
Cupcake	*Lactiplantibacillus plantarum*	Pectin[b], maltodextrin[b]	Dong et al., 2020a
Cupcake	*Lactiplantibacillus plantarum*	κ-carrageenan[b]	Dong et al., 2020b
Cream-filled cake	*Lacticaseibacillus casei*	High-amylose resistant starch[b]	Zanjani et al., 2012
Cake	*Saccharomyces boulardii, Lactobacillus acidophilus, Bifidobacterium bifidum*	Gum arabic[b], β-cyclodextrin[b]	Tontul et al., 2018
Fermented rice cake (Khao-Maak)	*Saccharomyces boulardii*	Germinated black glutinous rice[a]	Cheirsilp et al., 2023
Muffin	*Lactiplantibacillus plantarum*	*Stevia rebaudiana*[a]	Lieu et al., 2022
Gluten-free cake mix	*Bacillus coagulans*	Inulin[a], resistant starch[a, x, z], maltodextrin[a, x]	Amini et al., 2022

a: direct usage, b: coating, x: used as an fat replacer, y: used as a sugar replacer, t: prebiotics were used in yoghurt for tarhana production, z: type of resistant starch is not defined

Biscuit/cookie

Table 2. The potential use of synbiotic combinations in biscuit/cookie

Product	Probiotic source(s)	Prebiotic or potential prebiotic source(s)	References
Cracker	*Lacticaseibacillus casei*	Inulin[b], whey[b], gelatine[b]	Garcia-Argueta et al., 2016
Biscuit cream	*Lactobacillus acidophilus, Lacticaseibacillus rhamnosus, Bifidobacterium bifidum*	Inulin[b], guar gum[b], xanthan gum[b], maltodextrin[b]	Muzaffar and Sharma, 2018
Gluten-free cookie	*Levilactobacillus brevis*	Inulin[a, x]	Chavez et al., 2022
Gluten-free biscuit	*Lactobacillus acidophilus*	Inulin[b], fructoologosaccharide[b]	Sumanti et al., 2020

a: direct usage, b: coating, x: used as an fat replacer, y: used as a sugar replacer, t: prebiotics were used in yoghurt for tarhana production, z: type of resistant starch is not defined

Pasta/noodle

Table 3. The potential use of synbiotic combinations in pasta/noodle

Product	Probiotic source(s)	Prebiotic or potential prebiotic source(s)	References
Pasta	*Bacillus coagulans*	Barley flour[a]	Fares et al., 2015
Pasta	*Lactiplantibacillus plantarum, Lactobacillus acidophilus, Limosilactobacillus fermentum*	β-glucan[a]	Arena et al., 2014
Noodle	*Lactiplantibacillus plantarum*	Fructooligosaccharide[b]	Rajam et al., 2015
Whole-grain pasta	*Bacillus coagulans*	β-glucan[a]	Angelino et al., 2019

a: direct usage, b: coating, x: used as an fat replacer, y: used as a sugar replacer, t: prebiotics were used in yoghurt for tarhana production, z: type of resistant starch is not defined

Other solid cereal-based foods

Table 4. The potential use of synbiotic combinations in other cereal-based solid foods

Product	Probiotic source(s)	Prebiotic and potential prebiotic source(s)	References
Breakfast cereal	*Saccharomyces boulardii*	Acacia gum[b], methylcellulose[b], carboxymethylcellulose[b], modified starch[b], maltodextrin[b]	Singu et al., 2020
Waffle filling	*Lactobacillus acidophilu, Bifidobacterium bifidum*	Inulin[a, x], pectin[b], lactulose[a,y]	Orgachev et al., 2019
Traditional fermented food[t] (Tarhana)	*Streptococcus thermophilus, Lactobacillus acidophilus, Bifidobacterium bifidum*	Inulin[a], lactose[a]	Shreef et al., 2010

a: direct usage, b: coating, x: used as an fat replacer, y: used as a sugar replacer, t: prebiotics were used in yoghurt for tarhana production, z: type of resistant starch is not defined

Human health

Table 5. Influence of potential synbiotic combinations in solid cereal-based foods on health

Major findings	References
Feeding of experimental rats with synbiotic biscuits (5g or 10 g in 10 mL aquadest) including *L. acidophilus*, inulin, and fructo-ologosaccharide: Total blood cholesterol level ↓ HDL cholesterol ↑ LDL cholesterol ↓	Sumanti et al., 2020
Consumption of synbiotic whole-grain pasta composed of *B. coagulans* and β-glucans for 12 weeks by healthy overweight or obese volunteers (*n*=41): Plasma LDL/HDL cholesterol ratio ↓	Angelino et al., 2019
Consumption of 200g/day dried tarhana, which is prepared from yoghurt containing inulin (3%) and lactulose (3%) fermented by 4.5% probiotic culture, for 45 days by hyperlipidemic volunteers (*n*=15): Total plasma cholesterol↓ Triglycerides↓ Low-density lipoproteins	Shreef et a., 2010

CONCLUSION

- Tthe following in vivo and in vitro studies should center around the survivability of more probiotic microorganisms, especially the lack of ***Bifidobacteriaceae*** **family**
- **Optimization of encapsulation process**, with different prebiotic sources at different levels utilized in particularly **gluten-free** cereal-based solid food products
- Not only viability of probiotics with prebiotics but also **nutritional, technological and sensorial** properties of cereal-based solid food products should also evaluated regarding their synbiotic potential.
- The potential **synbiotic combinations in cereal-based liquid food products such as juices/beverages** should be addressed in other studies.

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