General Perspective and Assessment of the Potential of Utilizing Paraprobiotics in Food Products

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"Probiotics, live microorganisms which, when administered in adequate amounts confer a health benefit on the host"

Probiotics will be affected by:

- The food’s composition: Water activity, Antibiotic content
- Processing conditions: Temperature, Time, pH
- Storage conditions: Oxygen content, Packaging materials

Problem:
- Adding probiotics during food processing
- Survival of microorganisms
- Shelf-life stability
- Proper delivery to the gut microbiota

(FAO/WHO, 2001; Hill et al., 2014)
Paraprobiotics are non-viable microbial cells that, when administered in adequate amounts, confer some health benefits to the consumer.

Advantages of paraprobiotics:
- Stability over a wide pH and temperature range
- No interaction with other components in the food matrix
- Easy food processing, industrial usage, commercialization
- Extending the shelf life of food
Figure 1. Inactivation Methods to Produce Paraprobiotics (de Almada et. al., 2016)
Inactivating enzymes

Lowering intercellular pH

Denaturing or altering the structure of nucleic acids

Denaturing or altering the structure of ribosomes

Damaging cell walls

Denaturing proteins

Damaging cell membrane

Damaging DNA

Figure 2. Changes in bacterial cell during inactivation of probiotics

(Lado et. al., 2002)
Figure 3. Paraprobiotic Assessment Methods

- **SEM**
- **PCR**
- **Plate Counting**
- **Flow Cytometry**

(Ananta and Knorr, 2009)
Modulating the Immune System

Recovery of Intestinal Injuries

Alleviate the Symptoms of
Diarrhea
Inflammation
Lactose Intolerance
Respiratory Diseases
Liver Diseases

Lower Cholesterol
Reduce Stress and Anxiety

Treatment of Dental Caries
Atopic Dermatitis
Colitis
Intestinal Lesions
Visceral Pain

Figure 4. Health Benefits of Paraprobiotics

(de Almada et. al., 2016; Grześkowiak et. al., 2014; Shin et. al., 2010)
<table>
<thead>
<tr>
<th>Probiotic strain</th>
<th>Food matrix</th>
<th>Inactivation method</th>
<th>Results</th>
<th>References</th>
</tr>
</thead>
</table>
| *L. acidophilus* and *B. lactis* | Yogurt              | Heat treatment (121°C, 15 min)         | Viscosity↑  
WHC↑  
Syneresis↓  
Storage modulus↓  
Loss modulus↓  
Stress crossover point↓  
Loss tangent↓  
Sensory properties↑  
*L*↔  
a*↔  
b*↔  
*pH*↓  
Acidity↑  
Redox potential↑ | Molaee Parvarei et. al., 2021a, 2021b, 2021c |
| *L. casei* subsp. *paracasei* 01 | Whey-grape juice    | Ohmic heating (8V/cm, 95°C/7min, 60 Hz) | Glucose rate↑  
Maximum glucose value↔  
Glucose incremental percentage↔  
Peak blood glucose time↔, Glycemic responses  
(AUC, AIg, PGV, HP, GB)↔  
Glucose postprandial level↓ | Barros et. al., 2021 |
CONCLUSION

- The paraprobiotic term has been evolving and gaining attention in recent years.
- Clinical studies demonstrated that paraprobiotics have health benefits for the consumers like probiotics. Therefore, paraprobiotics can be an alternative to probiotics for people with a sensitive immune system or who are immunocompromised/immunodeficient and avoid probiotic consumption.
- Also, paraprobiotics can be used when the use of probiotics is a technological challenge. In the case of processing and shelf-life conditions, not convenient probiotics survive.
- However, there isn't enough information and research in the literature about paraprobiotics just yet.
- The mechanism of action of paraprobiotics is not fully understood and requires further investigation.
- In this regard, the following studies should focus on determining valid conditions for emerging inactivation methods, the biological activities and stability of paraprobiotics in vitro and in vivo, and the terms for wide application and easy commercialization of paraprobiotics.
- Furthermore, it's critical to establish a precise definition by subject-matter experts and prevent the misuse of paraprobiotics.
REFERENCES


THANK YOU FOR YOUR ATTENTION