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Review Article

Biotechnological Applications in Enhancing the Gut Environment

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ABSTRACT

Modern technologies of biotechnology which are involved in modifying the composition of some food ingredients, play an important role in the food industry that stimulates intestinal movement. Focusing on some key genes of significance in the regulation of immunity, growth and nutrient metabolism in different tissues. Also, using fermentation techniques in the food industry is important. Probiotic bacteria especially *lactobacillus spp.* is continuously developing to modulate the microbiome of the gut, furthermore it can be considered a novel alternative medication for overweight problems and other metabolic deficiencies. Administration of probiotic organisms can modulate the gut microbiota for host health recovery. Fungi and yeasts in particular, and the most prominent of them are *Saccharomyces spp.* they have an important role in reducing gastrointestinal diseases, and reducing intestinal invasion with harmful fungal species, in addition to their presence in foods that reduce poor digestion to a great extent.

Keywords: probiotic bacteria, probiotic yeast, biotechnology, gut microbiome.

INTRODUCTION

Biotechnology is considered an important solution to enhance food quality, improve food constituents, and produce safe and functional food suitable for digestion by humans (Mustafa *et al.*, 2018; Bentahar *et al*., 2023). Probiotic bacteria are valuable in improving human health, by introducing them into a fermented diet safely, and security assessment is fundamental in such utilitarian food (Abdullah, 2017). Bacterial prebiotics are fibers of fermented constituents that stimulate growth, and promote one or few bacterial species in the gut microbiota, which award the health of the host (Jamar *et al.*, 2020). The term synbiotic is to characterize the use of both probiotic and prebiotic admixture that is advantageous for the human gastrointestinal system (Anadón *et al.*, 2019). Probiotic bacteria are known as live non-pathogens, which enhance the health benefit when administer in appropriate amounts, and we can see their wide applications in infants, pregnancy, children, and adults in different health conditions (de Brito Alves *et al.*, 2020). The synbiotic combination of *Cudrania tricuspidata* leaf extract and fermented milk with *Lactobacillus gasseri* , thus, through examination of several functions of colon barriers, apoptosis, inflammation and the regulatory pathways, the result was indicated that synbiosis had a naturally potential effect against colon cancer (Oh *et al.*, 2020). Alleviation of nonalcoholic fatty liver disease (NAFLD) and obesity will assist by the administration of resveratrol (RSV) and *Bifidobacteria longum* individually, on the other hand, administration of probiotic *B. longum* and prebiotic RSV synergistically would be a potential prospect or attendant factor for treatment of NAFLD and obesity (Hu *et al.*, 2020).

Moreover, in vitro addition of prebiotic such as high molecular weight dextran to a system with fecal microbiota inoculum, at most enhance the proportional amount of *Bacteroides* and *Prevotella* consistently with a convenient ratio of acetate-propionate, resulting in a hopeful utilization as a functional supplement in the food industry (Amaretti *et al*., 2020).

Fungi are considered to have an important role in the manufacture of nutritional supplements, for example they stimulate growth in the food of some types of chicken. *Aspergillus awamori* has an important role as it was used as alternative to the antibiotics given to broiler chickens, and thus the result was good health and excellent meat quality (Saleh *et al.*, 2014). There are no many types of fungi that grow and settle in the intestine and digestive system, among the most famous of these types are the Candida yeasts and some members of the Dipodascaceae family. Other species such as *Saccharomyces cerevisiae* works as diet, *Aspergillus* species works as probiotic, They have an influence on the environment of the gut, directly or indirectly (Hallen-Adams and Suhr, 2017).

The nutritional value of health-supportive bacteria and fungi

The standard criteria required for suitable bacteria to be considered as optimum probiotic food include, survival of strain in processing, packaging and formulization of product, product-shelf life, bacterial stability, quality and safety, stability, adherence and colony formation inside the intestinal wall, anti-pathogenic activity, biological action besides tolerate stress conditions of the gastrointestinal tract, activation of the immune system, lastly health support to the host, Fig. (1) (Jackson *et al.*, 2019). The role of bacterial adhesion is advantageous in the interaction between food components and the surface of probiotics biomolecules, and gradually to foretells the bacterial location within a food matrix, which in sequence, can have the capacity to improve probiotics transport toward the surfaces of mucosa in the oral cavity (Monteagudo-Mera *et al.*, 2019).

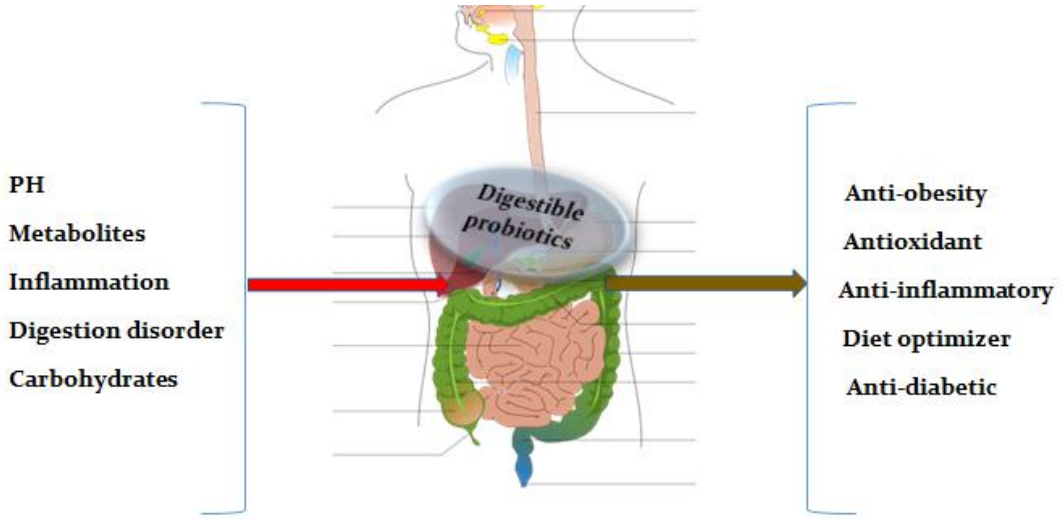

Fig. 1: Role of industrialized probiotics

Several types of phytic acid-rich foods such as corn steep liquor, oothappam, pearl millet, shalgam, sourdough, soybean tempeh, kara tempeh, fermented gruel, uttapam batter, kimchi and many other fermented food of Lactic acid bacteria (LAB) (Damayanti *et al.*, 2017). Also some milk products sources such as raabadi and hatay boiled cheese (Basu *et al.*, 2015). A genomic-based research on gut and food bacteria by using more than 150 thousands human metagenome-assembled genomes (MAGs), along with 666 MAGs newly fermented food microbiomes and about 193 thousands reference genomes, the genomic analysis revealed that LAB strains appear in both gut and food media and proved that fermented food could act as the optimum source of LAB for the human gut microbiome (Pasolli *et al.*, 2020). *Saccharomyces boulardii* is an important example of yeast probiotic, and among its most prominent characteristics is that it tolerates high temperatures, and in other experiments and analyses worked on laboratory animals, it has been proven that *S. boulardii* has a therapeutic role in humans, Also, some clinical trials have proven that *S. cerevisiae* and *S. boulardii* have a positive role in treating some digestive canal disorders (Sen and Mansell, 2020). Strains of *Kluyveromyces lactis, S. boulardii and S. cerevisiae* may be considered as probiotics, in normal status these yeasts can activate the immune system and this is highlighted through expression of cytokine and Toll-like receptors, which have a distinctive role in preserving the host's immunity, and thus good results can be seen in resisting inflammatory infections (Kourelis *et al.*, 2010).

Contribution of bacteria and fungi in industrial biotechnology

Biotechnological processes are valuable in the decreasing of carcinogenic acrylamide, via lactose degradation in dairy, or acrylamide in potato crisps and bread, furthermore, biotechnological approaches can convert woody-rich ingredients of the plant into components that are more suitable for human and animal diets (Popa *et al.*, 2019). Synergism between fermenting organisms in food leads to inhibit the growth of pathogens, through secondary metabolites forming by fermented microorganisms (Di Cagno *et al.*, 2013)**.** *Lactobacillus* bacteria is one of the most popular contributors to the functional food industry. *L. acidophilus* has been already enhancing the fecal quality and totally decreasing coliforms count (Fusi *et al.*, 2019). Fig. (2).

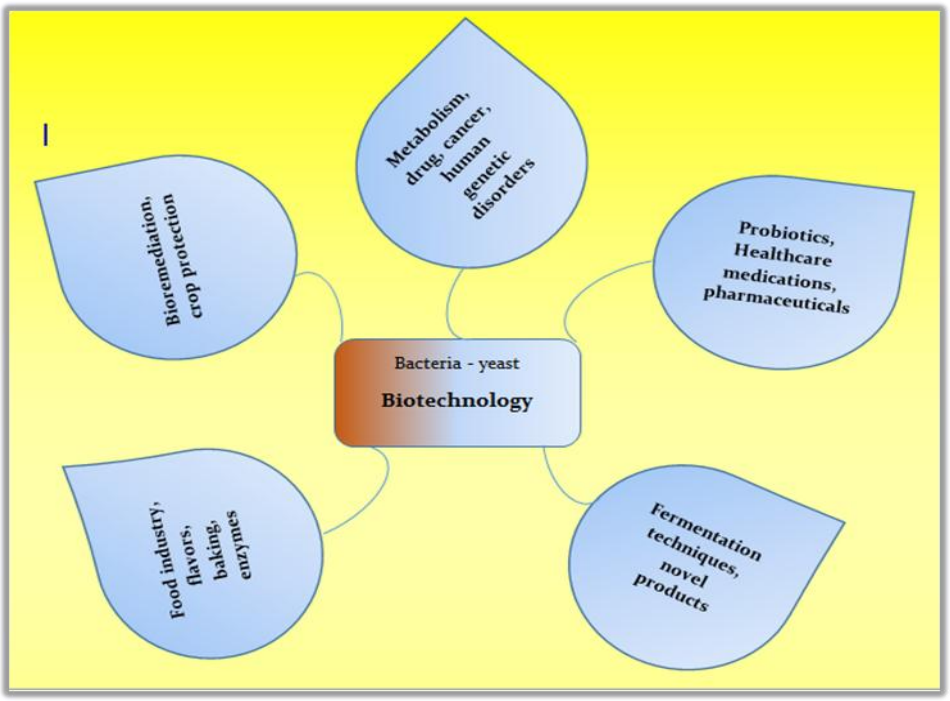

Fig. 2: Participation of bacterial, yeast biotechnology in protection and different industries.

Additionally, researches showed boosting in the morphological characteristics of the gut, and alteration in microbiota and metabolome of the gastrointestinal tract during administration with the same probiotic (De Cesare *et al.*, 2020). Mixing and encapsulation of *L. casei* and aqueous extract of black beans, through freeze drying in combination with biopolymers such as chitosan, insulin and whey protein with encapsulation capacity of 99.33 ± 0.13% for anthocyanins and 77.42 ± 1.34% for LAB respectively (Enache *et al.*, 2020). Recent data confirmed the competence of encapsulatants biomaterials with probiotics in the environment of the stomach and ensure their complete release in the intestine (Liu *et al*., 2021). To illustrate the antipathogenic function of bacterial probiotics, human pathogens such as *Aureobasidium pullulans*, *Propionibacterium acnes* and *Staphylococcus epidermis* could be inhibited by the addition of *Arthrospira platensis* biomass protein and polysaccharide fractions to unpasteurized apple juice (Wajda *et al.*, 2020). Moreover, functional food of *L. Plantarum* and *L. Casei* utilized as ingredient of anticancer effect against human SW480 cell line-colon adenocarcinoma, via optimizing particular proteins related with cell motility, associated with the inhibition of epithelial–mesenchymal transition, and the collapse of extracellular matrix (Lizardo *et al.*, 2020).

Combination between *Saccharomycopsis fibuligera* yeast, wheat bran fibers, exopolysaccharide and povidone in order to form nanofibers, by the use of electrospinning process, this mixture of nanoparticles and fungi can be used in the food industry that improves the efficiency of the digestive system (Ragavan and Das, 2020). *S. cerevisiae* also has an important effect in reducing the side effects resulting from high temperatures, as it was tried in laboratory mice orally before being exposed to overheating, the results showed a maintenance in the expression of junction proteins, and reduction goblet cells balance, and this can be explained by Apbiotic Khmer, which was used to protect gut environment (Ducray *et al.*, 2019).

Probiotics in Cancer

Recently, probiotics have become widely used to promote health without resorting to prescriptions from a doctor, as many studies have proven that probiotics can significantly contribute to improving the body's immune system as well as enhancing intestinal health, in rare cases, it may negatively affect the health of the body. As for the studies that dealt with the role of probiotics in reducing cancer, the results were contradictory, so the feasibility of using it to target cancer and

reduce the side effects of the medications used requires further research. However, many laboratory studies have proven the possibility of using probiotics to regulate the proliferation and death of cancer cells. For example, it had an effective role in inhibiting rat colon cancer cells HGC-27 and human colon cancer cells Caco-2. Probiotics can also contribute to increasing the production of SCFAs, which in turn prevents pathogens, furthermore, SCFAs may play a role in the regulation and response of systemic immunity (Dos Reis *et al*., 2017). SCFAs reviving intestinal epithelial cells to make antibacterial peptides and increase the exhibition of tight junctions to settle down intestinal partition function. SCFAs infleunce inflammation by reactive with G protein-coupled receptors in the intestine and steady the immune response (Orlando *et al*., 2012).

CONCLUSION AND RECOMMENDATIONS

Biotechnological food processes are of great interest in healthy food production, which in turn enhances health and reduces illnesses such as osteoporosis, and cardiac diseases. In turn this will lead to supporting immunity, providing more energy. More future approaches are needed for the use of probiotics, prebiotics, or synbiotics for modulating the gut microbiomes, overweight and other metabolic disorders in the near future, and for the intestinal degradation of non-digestible carbohydrates. Yeasts have a special role rather than other types of fungi as they act as nutritional supplements and have a prominent role in the digestive system and gastrointestinal disorders. This has been proven through many pre-clinical trials. Genetic engineering processes of *S. cerevisiae* can be applied to *S. boulardii* to improve their nutritional performance. Where genetically engineered yeast could be used in future research that could lead to the development of nutritional supplements or healthy food. Poor societies should have the chance to obtain probiotics and bacterial fermented food, in order to decrease the risk of infections, malnutrition and diabetes. In clinics, and for future work, it is necessary to add laboratory tests, about the interaction of nutritional supplements with other medicines, and on the patient's condition to ensure normal use in the food supplement. Governments should have more investigations and researches in reducing the side effects of bacterial probiotic, in order to be applicable. Furthermore, we recommend to enhance encapsulation techniques to guarantee that probiotic will still alive for elongated period.

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تطبيقات التقانة الأحيائية في تحسين بيئة القناة الهضمية

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الملخص

تلعب التقنيات الحديثة للتقانة الحيوية التي تساهم في تعديل تكوين بعض المكونات الغذائية دورًا مهمًا في صناعة الأغذية التي تحفز حركة الأمعاء. ويكون التركيز على بعض الجينات الرئيسية ذات الأهمية في تنظيم المناعة والنمو واستقلاب المغذيات في الأنسجة المختلفة. بالإضافة الى اهمية استخدام تقنيات التخمير في صناعة الأغذية. يكون تعديل بكتريا البروبيوتيك probiotics خاصة *Lactobacillu*s spp. مستمرا لتحوير ميكروبيوم الأمعاء علاوة على ذلك، يمكن أن تعتبر دواءً بديلاً جديدًا لمشاكل زيادة الوزن وغيرها من أوجه الخلل الأيضي. يؤدي إعطاء كائنات البروبيوتيك إلى تعديل ميكروبيوتا الأمعاء واستعادة صحة المضيف. يكون للفطريات والخمائر وعلى وجه الخصوص *Saccharomyces* spp. دور مهم في الحد من أمراض الجهاز الهضمي، وتقليل الغزو المعوي بالأنواع الفطرية الضارة، بالإضافة إلى وجودها في الأغذية التي تقلل من سوء الهضم إلى حد كبير.

الكلمات الدالة: بكتيريا البروبيوتيك، خميرة البروبيوتيك، التكنولوجيا الحيوية، ميكروبيوم الأمعاء.