Chapter

Single Strain Probiotic Bifidobacteria Approach in Health and Non-Health Fields

Hüseyin Sancar Bozkurt and Havva Bozkurt

Abstract

Single strain probiotic bifidobacteria approach is promising for the future in health and non-health fields. Recent studies show that intestinal lumen microbial content and tissue microbial content are different, so the personalized microbiome approach with the 16S rRNA analysis comes to the fore with the single strain probiotic bifidobacteria (BB-12,Infantis) approach. In addition to their immune modulation effect, they have beneficial effects such as preventing pathogens from binding to the intestinal mucosa via the biofilm layer they produce, and also their electrophysical properties in various atmospheric conditions, They have the ability to be used in non-health areas such as microplastic biodegradition, nanostructures, food and agriculture fields. The availability of single strain probiotic bifidobacteria in health, ecological and food systems are signs that progress in the single strain probiotic bacteria approach will be more accurate.

Keywords: probiotic, bifidobacteria, health, ecology

1. Introduction

Probiotic bifidobacteria are living microorganisms that have beneficial immunomodulatory effects on human health and have fermentation properties. They can play a role in the management of dysbiosis-related intestinal disorders such as colon cancer, IBD, Celiac, IBS, as well as virological disorders such as SARS-Cov-2 and neurologic disorders. Although there are many scientific studies on the effects of single strain of probiotic bifidobacteria on human health, there are very few publications on their behavior and interactions in various atmospheric conditions other than the human body. In this section, we present the effects of single strain of probiotic bifidobacteria approach in the field of health, as well as the electrophysiological behaviors and interactions in various atmospheric conditions with different materials.

1.1 Single strain of probiotic Bifidobacteria approach in the field of health

1.1.1 Single strain of probiotic Bifidobacteria in gastrointestinal disorders

As we discussed in detail in our previous work [1], the human intestinal microbiota includes commensal, symbiotic, and pathogenic bacteria species [2, 3]. It was demonstrated that intestinal microbiota have anti-inflammatory features and

contribute to the immune, neuroendocrine, and metabolic homeostasis of the host [4, 5]. The genus Bifidobacterium in gut microbiota is Gram-positive, non-motile, often branched anaerobic bacteria and it belongs to the phylum Actinobacteria [1]. Bifidobacteria are one of the dominant species in the human gut microbiota and are frequently used as probiotics [6]. *B. animalis* subsp. *lactis* exerts the highest level of intracellular hydrogen peroxide resistance among Bifidobacteria and provide protection against reactive cellular oxygen species [7]. Reduced bifidobacteria levels are associated with inflammatory bowel disease (IBD) [8, 9]. *B. infantis* 35624 has been shown that reduced plasma pro-inflammatory biomarkers in IBD and extra-intestinal inflammatory disorders [10].

Also, the administration of *B. infantis* 35624 was associated with a significant reduction in plasma pro-inflammatory biomarkers in patients with psoriatic disorder and oral administration of *B. infantis* 35624 modulates the cytokine across both gastrointestinal and non-gastrointestinal inflammatory disorders and healthy subjects. In our previous study [11], endoscopic single *Bifidobacterium animalis* subsp. *lactis* and xyloglucan administration was found effective in the mucosal healing and resolution of colonic symptoms in ulcerative colitis patients (**Figures 1** and **2**) [11].

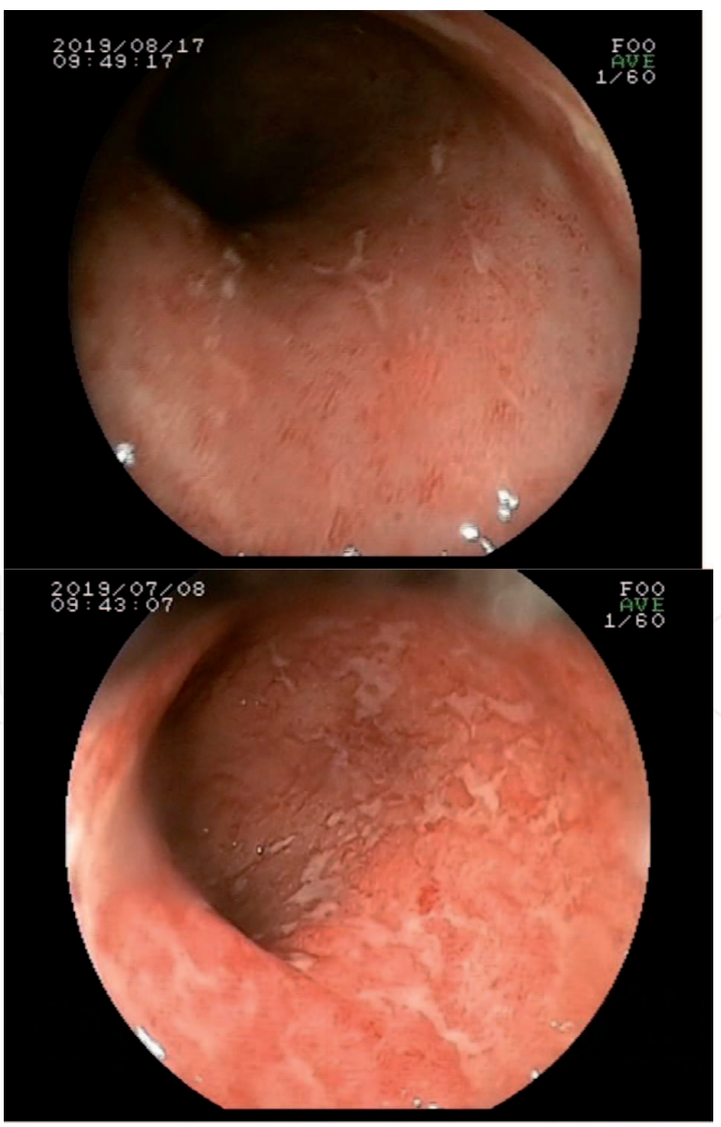

Figure 1.
Mucosal healing (upper) within one month after a single intracolonic application of 200 billion colony forming units (CFUs) of Bifidobacterium animalis *sp.* Lactis *and 4 gr Xyloglucan combination in unresponsive ulcerative colitis (below) [11].*

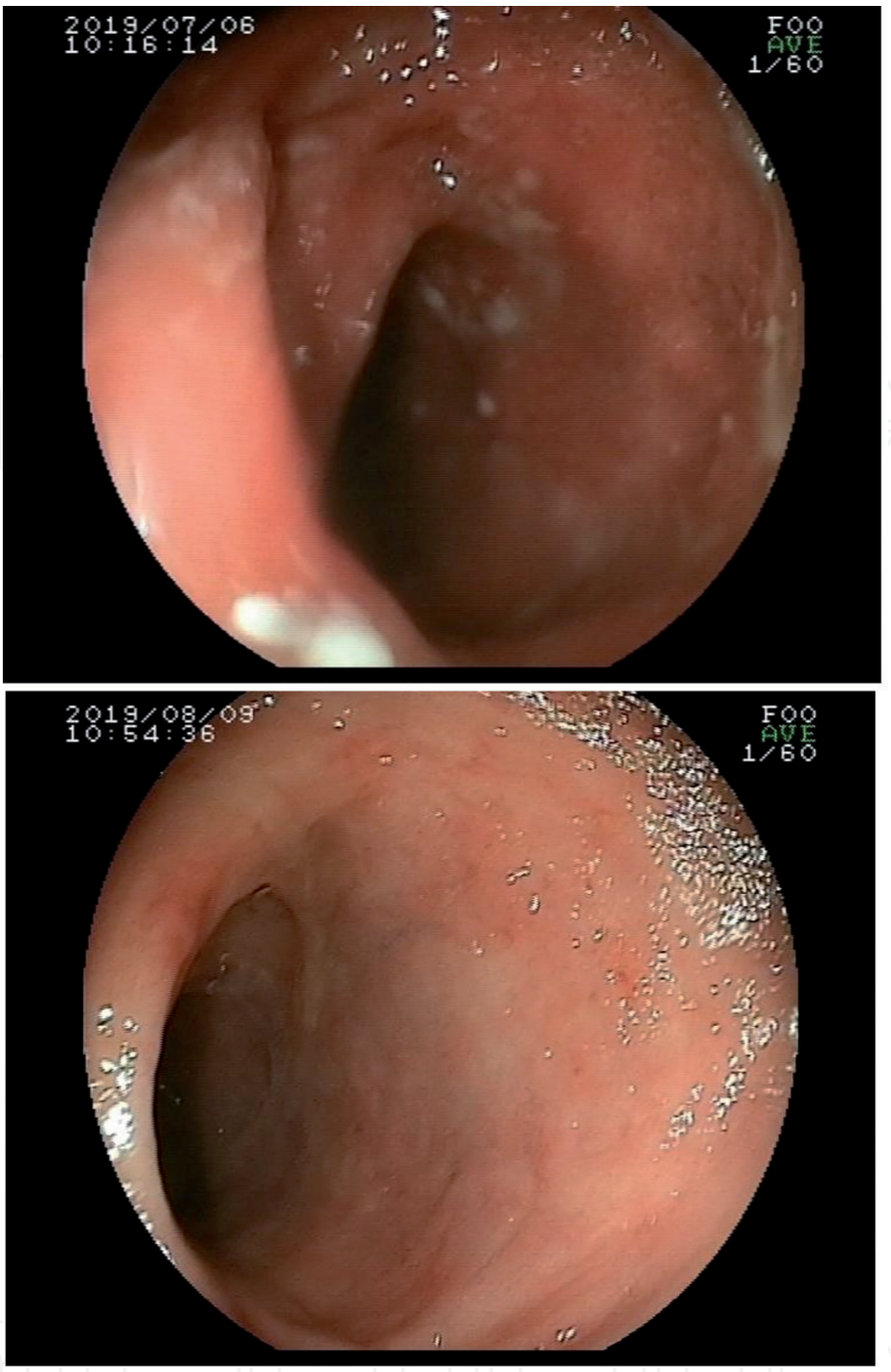

Figure 2.
Mucosal healing (below) within one month after a single intracolonic application of 200 billion colony forming units (CFUs) of Bifidobacterium animalis *sp.* Lactis *and 4 gr Xyloglucan combination in unresponsive ulcerative proctosigmoid colitis (upper) [11].*

The use of single strain probiotic bifidobacteria such as BB-12 and Infantis in effective and appropriate doses can be considered an effective treatment method for intestinal and extraintestinal disorders.

Another aspect of the single strain probiotic bifidobacteria is that they are suitable candidates for the next generation probiotic. As we discussed in detail our previous study [1], With the Open Reading Frame (ORF) method, these species can be guided by genetic coding for postbiotic production [12]. Mycosporin amino acids are a viable target for this situation. Mycosporin-like amino acids (MAAs) are low molecular weight amino acids. MAAs act as absorbers of ultraviolet (UV) light and as photo protectants which are unique components of red seaweeds [13]. Seaweed products are used as nutritional supplements in the management of bowel diseases.

MAAs also play a key role in protecting against sunlight damage by acting as antioxidant molecules scavenging toxic oxygen radicals. MAAs have been described to affect the intestinal mucosa, enhancing villus structure, as well as the intestinal microbiota, increasing the abundance of Bifidobacterium and, importantly, reducing the prevalence of Clostridium species in animal models [14]. Also, modulation of NF-κB and tryptophan metabolism via MAAs has a beneficial effect on the gut immune system. Besides these features, MAAs also inhibit thiobarbituric acid reactive oxygen species which are increased in colon cancer.

In this context, MAA-producing single strain *Bifidobacteria* species via ORF could result in a bacterium that is more potent in the prevention of dysbiosis associated disorders such as IBD, CRC, Chronic inflammation. Also, MAAs produced via ORF might be used not only as a probiotic but also as a pharmacological agent in intestinal disorders.

1.1.2 Single strain probiotic Bifidobacteria in Sars-Cov-2 management

As we reported in our previous study [15], Sars-Cov-2 is a pandemic virus that manifests itself with respiratory distress as well as leading to symptoms and signs associated with the gastrointestinal tract. Sars-Cov-2 is especially manifested by the disturbed adaptive immune status in lung and intestinal tissues which is called 'cytokine storm'. During their cellular replication, viral pathogens such as Sars-Cov-2 increase endoplasmic reticulum stress and exert their autophagy inducing effects through the adaptive TH17 / IL17 system and this leads to an uncontrolled immune response [15]. The cytokine storm can be modulated through immune effects of strain specific probiotic bifidobacteria. In our previous study, *Bifidobacterium animalis* sp. Lactis-BB12 led to rapid mucosal healing in ulcerative colitis patients [11] and this effect was related to the IL-17 inhibitory effect of the BB-12 strain. IL-6 promotes the generation of Th17 cells and that IL-6 and IL-17 synergistically promote viral replication and *B. infantis* 35624 could reduce the systemic inflammatory biomarkers such as IL-6,CRP, TNF alpha [15]. Also, *Bifidobacterium infantis* reduced the duration of acute respiratory infections illness in children and adults [16]. The administration of booster of an appropriate strain of bifidobacterium (such as BB-12, or infantis) especially in patients with gastrointestinal symptoms (diarrhea, abdominal pain, vomiting), may be postulated to have a role in the management of coronavirus infected patients (**Figure 3**).

1.1.3 Single strain probiotic Bifidobacteria in vaccine development

Gut dysbiosis might play a role in the failure to respond to vaccines. In this regard, gut microbiota could affect intestinal immune responses by acting as

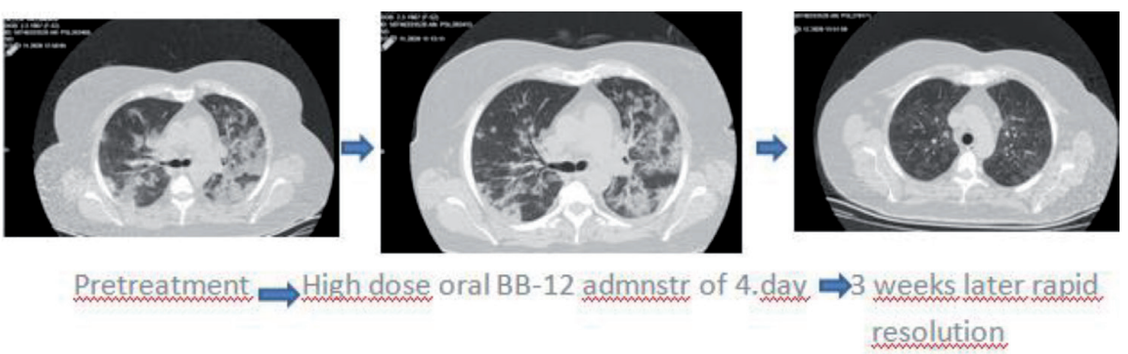

Figure 3.
Rapid radiologic enhancement of high dose oral Bifidobacterium *BB-12 administration in severe Sars-Cov-2 [15].*

immune modulators as well as natural vaccine adjuvants [17]. The administration of the probiotic strain *Bifidobacterium* BB-12 significantly increased antigen-specific immune responses in healthy individuals receiving influenza vaccination [18]. Also, Exopolysaccharide produced by *B. longum* 35624 played an essential role in the anti-inflammatory effects of this bacterium and removal of exopolysaccharide (EPS) resulted, not only in loss of these anti-inflammatory effects, but to a transformation to become an inducer of local TH17 responses [19]. In some experiments, EPS- protein conjugate vaccines could enhance immunogenity [20]. Our studies revealed that the maintenance of the unique electrophysiological properties of BB-12,Infantis in an aerobic environment for up to 6 months could be attributed to the integrity of their unique EPS structure [21]. Hence, the single strain probiotic bifidbacterial polysaccharide cell structure can be considered as a lipopeptide based vaccines.

Since the relationship between viral replication and gastrointestinal immunity is very close, an appropriate approach over probiotic bifid bacteria can play an important role in reducing viral replication. New approaches to the single strain probiotic bacteria can be promising, both in terms of vaccination and treatment models.

2. Single strain probiotic Bifidobacteria in non-health fields

2.1 Electrophysiological properties of Bifidobacterium BB12 and infantis

2.1.1 Bifidobacterium BB-12

As we cited in our previous study [1], BB-12 is technologically well suited, expressing fermentation activity, high aerotolerance, good stability and a high acid and bile tolerance. Because of high redox potential in the colon microbiota ecosystem, BB-12 is highly resistant bacteria in distress condition. The BB-12 cell envelope is an electrical and physical barrier that that consist of redox proteins. Bacterial cellular electron transfer systems (CET) are defined microbial bioelectrochemical processes in which electrons are transferred from the cytosol to the membrane of the cell [22, 23]. Charge transport behavior and the effect of the Relative Humidity (RH) level on it in the BB-12 film have been investigated by means of I-V measurements. Within aqua moisture environment, electrical conductivity of the BB-12 increased more than six decades while under N environment conductivity returns to the initial current value (**Figure 4**).

This behavior in conductivity modulation was reversible at least in the three cycle [21].

As we stated in our study [21], this experimental findings showed us that there was no structural transformation under relative humidity. On the other side, increase in the conductivity was interpreted by the increase in the population of charge carries, supplied by the interaction BB-12 with the water moisture, monitored by amine and carboxyl group through FTIR and Zeta potential measurements. The type of surface charge of *Bifidobacterium animalis* subsp. *lactis* BB-12 was found to be negative by zeta potential measurements, claiming that electrons were the charge carriers. Overall, obtained result in this study indicated that *Bifidobacterium* BB-12 has a great potential for humidity sensing device at room temperature.

2.1.2 Bifidobacterium Infantis

B. infantis 35624 is probiotic commensal bacteria that dominates the intestinal microbiota of breastfed babies and by accelerating and balancing the maturation of

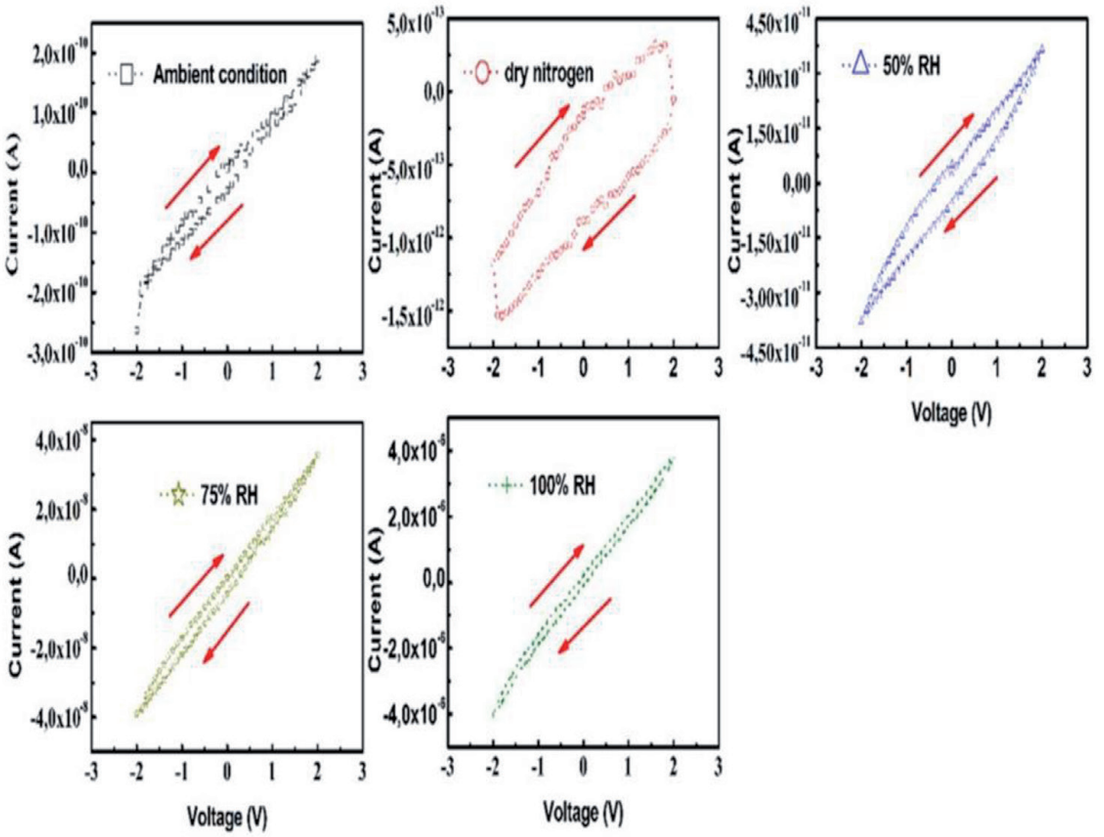

Figure 4.
I–V characteristics of the film of Bifidobacterium animalis subsp. lactis BB-12 at various RH levels.

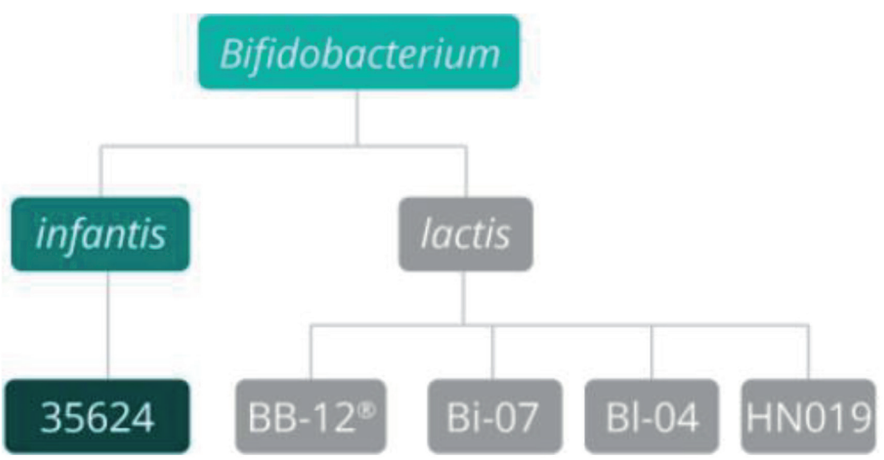

Figure 5.
Bifidobacterium Infantis.

the system and that improves intestinal barrier function and also benefits the host by increasing acetate production (**Figure 5**).

Interaction of aqua molecules with the surface of the *Bifidobacterium infantis* film leads to an increase. Increase in sensor current to a nearly constant value within a few minutes. Increase in sensor current, with aqua molecules, the interaction between bifidobacteria and aqua is highly dependent on the molecular structure of the assays.

Sensor sensitivity increases with the increase in relative humidity, aqua on the film surface reveals that adsorption of molecules is a multilayer process. Room linear increase in sensitivity with relative humidity, sensors 0–90% relative humidity indicates that it can be used for practical applications in the sensing range (**Figure 6**).

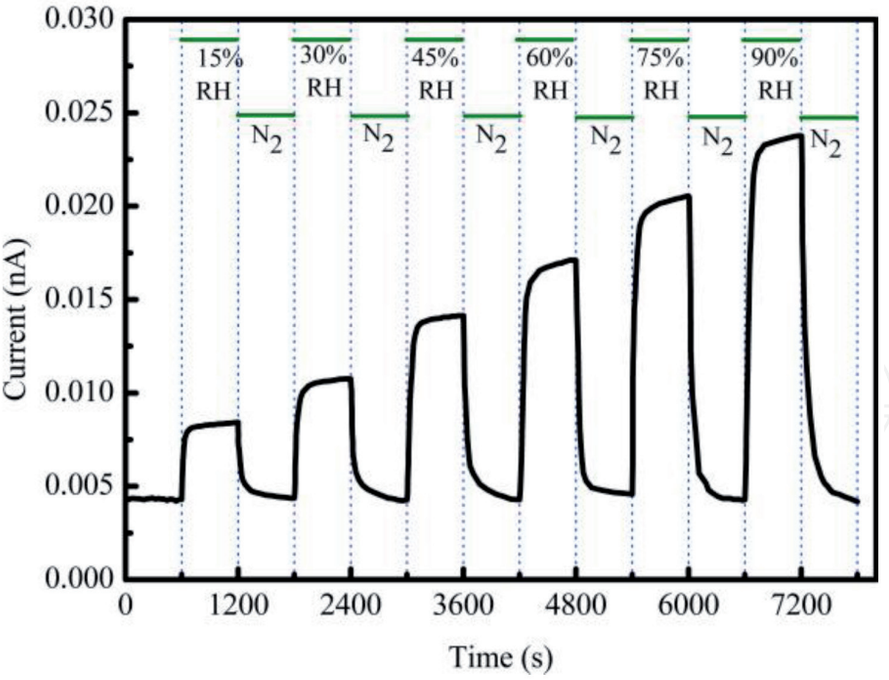

Figure 6.
Response-recovery behavior of Bifidobacterium infantis*-based sensor for various RH levels.*

3. Future approaches with single strain probiotic Bifidobacteria

Infection of medical equipment is one of the most common problems in the healthcare field, medical equipment infection can be prevented by probiotic bifidobacterial adhesion (**Figure 7**). Also, depending on the electrophysiological properties of these single strain probiotic bifidobacteria species, which have antimicrobial,

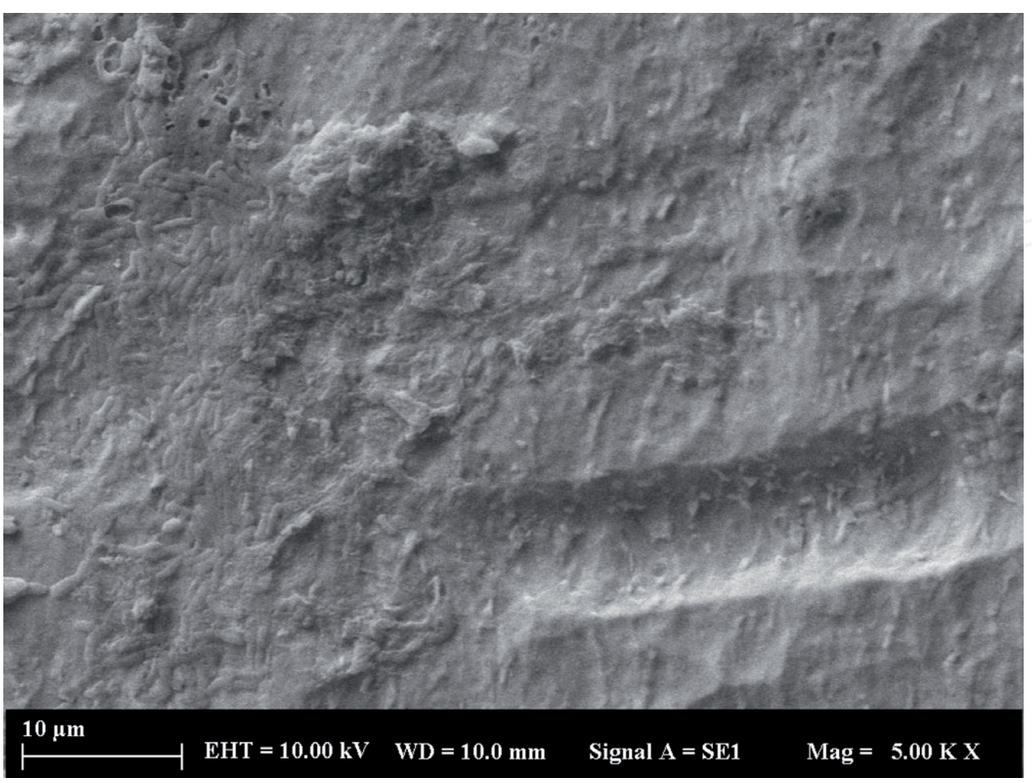

Figure 7.
Single strain probiotic bifidobacteria adhesion on medical orthopedic implant on scanning electron microscope (SEM) appearance.

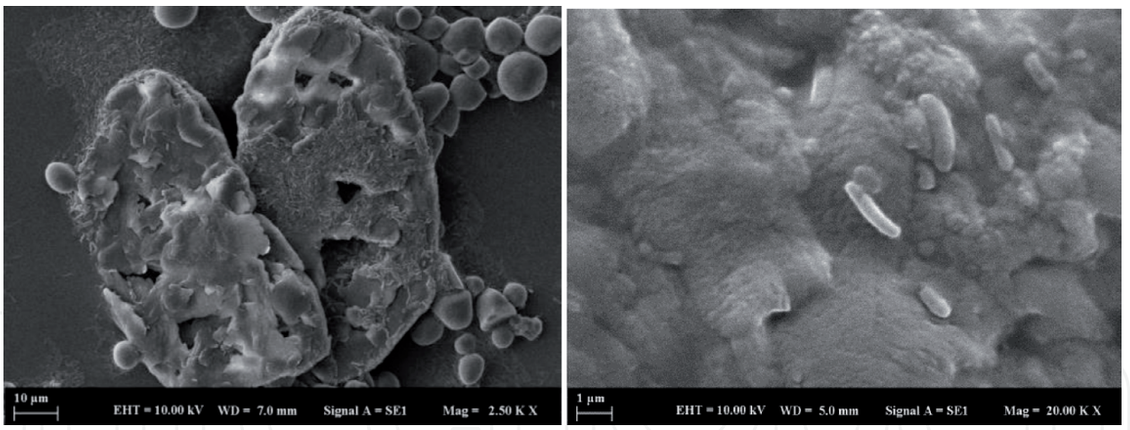

Figure 8.
Single strain probiotic bifidobacteria adhesion (left appearance of SEM) and biodegradation (right appearance of SEM EDS) on polypropylene microplastic.

immunomodulatory and beneficial effects on human health, they have paved the way for a new era in many areas such as agriculture, food, biodegradation of microplastics (**Figure 8**) and a healthy ecological system.

4. Conclusion

Single strain probiotic bifidbacteria approach is a promising approach in cases such as inflammatory bowel diseases, bowel disorders, virological disorders and colon cancer. Beside these, single strain probiotic bifidobacteria approach is promising for a healthy ecosystem depending on its behavior in atmospheric conditions.

Conflict of interest

The authors declare no conflict of interest.

Author details

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