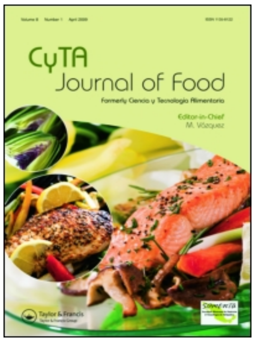

CyTA - Journal of Food

ISSN: 1947-6337 (Print) 1947-6345 (Online) Journal homepage: https://www.tandfonline.com/loi/tcyt20

Characterization, health benefits and applications of fruits and vegetable probiotics

Armachius James & Yousheng Wang

To cite this article: Armachius James & Yousheng Wang (2019) Characterization, health benefits and applications of fruits and vegetable probiotics, CyTA - Journal of Food, 17:1, 770-780, DOI: 10.1080/19476337.2019.1652693

To link to this article: https://doi.org/10.1080/19476337.2019.1652693

CYTA – JOURNAL OF FOOD
2019, VOL. 17, NO. 1, 770–780
https://doi.org/10.1080/19476337.2019.1652693

Taylor & Francis
Taylor & Francis Group

Characterization, health benefits and applications of fruits and vegetable probiotics

Armachius James and Yousheng Wang

Beijing Advanced Innovation Centre for Food Nutrition and Human Health, Beijing Technology and Business University (BTBU), Beijing, P.R. China

ABSTRACT

Probiotics are live microorganisms that confer health benefits to human when administered in adequate amount. They are mainly lactic acid bacteria (LAB) of the genera *Lactobacillus* and *Bifidobacterium*, although the probiotics potential of other bacteria and yeast are not excluded. Modulation of the immune system, anti-inflammatory effect, improved intestinal functioning, inhibition of pathogens and treatment of diseases such as traveler's diarrhea are among probiotics benefits. While several health ailments such as inflammatory bowel, diabetes, hepatic, neurological, respiratory and cardiovascular diseases and some cancer like colorectal cancer are associated with probiotics imbalances. Probiotics are mainly isolated from the human microbiota pool, feces, breast milk and fermented products. Also, fermented fruits and vegetable described as prebiotics are among sources of probiotics. They are rich in functional antioxidants that synergistically provides health benefits to human. In the present work, fruits and vegetable probiotics, isolation, characterization, health benefits and their application are reviewed.

ARTICLE HISTORY
Received 31 May 2019
Accepted 26 July 2019

KEYWORDS
Probiotics; prebiotics; fruits; vegetables; *Lactobacillus*; *Bifidobacterium*

PALABRAS CLAVE
Probióticos; Prebióticos; Frutas; Verduras; *Lactobacillus*; *Bifidobacterium*

Caracterización, beneficios para la salud y aplicaciones de probióticos de frutas y verduras

RESUMEN

Los probióticos son microorganismos vivos que brindan beneficios a la salud humana cuando son administrados en la cantidad adecuada. Se trata principalmente bacterias del ácido láctico (LAB) de los géneros *Lactobacillus* y *Bifidobacterium*, aunque no se excluye el potencial probiótico de otras bacterias y levaduras. Entre los beneficios ofrecidos por los probióticos pueden mencionarse: modulación del sistema inmunitario, efecto antiinflamatorio, mejor funcionamiento intestinal, inhibición de patógenos y tratamiento de enfermedades, por ejemplo, la diarrea del viajero. Por otra parte, diversas enfermedades, como intestino inflamatorio, diabetes, enfermedades hepáticas, neurológicas, respiratorias y cardiovasculares y algunos tipos de cáncer como el cáncer colorrectal, están asociadas con desequilibrios en los probióticos. Los mismos se aíslan principalmente del conjunto de microbiota humana, heces, leche materna y productos fermentados. Además, entre las fuentes de probióticos se encuentran las frutas y verduras fermentadas descritas como prebióticos. Son ricos en antioxidantes funcionales que proporcionan beneficios para la salud humana de manera sinérgica. En el presente trabajo se revisan los probióticos de frutas y verduras, y se estudia su aislamiento, su caracterización, los beneficios para la salud y su aplicación.

1. Introduction

Probiotics are live microorganisms that confers health benefit to human when administered in adequate amount, generally by improving or restoring the gut microflora (FAO/WHO, 2006; Lebeer et al., 2018). They include a viable mono or mixed culture of bacteria that beneficially improves the properties of indigenous gut microbiota when applied to human (FAO/WHO, 2006). Gut microbiota refers to microorganisms that colonize the entire human digestive system. Most of the probiotics belong to lactic acid bacteria (LAB) of the genera *Lactobacillus* and *Bifidobacterium* (Doğan, Tekiner, & DemirkesenBiçak, 2019). Others include *Bacillus, Lactococcus, Leuconostoc, Pediococcus, Enterococcus* and *Streptococcus* strains (Cutting, 2011; García-Ruiz et al., 2014; Le & Yang, 2018). They are mainly isolated from the human gut microbiota pool, feces, breast milk and fermented products (Fontana, Bermudez-Brito, Plaza-Diaz, Muñoz-Quezada, & Gil, 2013; Syngai et al., 2016; Tarrah et al., 2019). Probiotics strains have to be autochthonous of the environment where they will be a part once ingested. Other microbes may also have probiotics potential including some yeast strains of *Saccharomyces boulardii, S. cerevisiae, S. bayanus, S. florentius, S. pastorianus, S. sake, S. unisporus* and *Schizosaccharomyces pombe* and bacteria such as *Oenococcus oeni* (Pennacchia, Blaiotta, Pepe, & Villani, 2008; Tamang, Shin, Jung, & Chae, 2016). Probiotics effects can be strain specific, but may have more than one health benefits depending on their delivery method, host response or interaction with other microbes (Reid, 2016).

Probiotics competitively inhibit growth and proliferation of pathogens such as *Escherichia coli, Bacillus cereus, Listeria monocytogenes, Staphylococcus aureus* and *Clostridia* spp. in the gastral intestinal tract (GIT) (Floch, 2018; Ghasemian, Eslami, Shafiei, Najafipour, & Rajabi, 2018; Panghal et al.,

---

CONTACT Yousheng Wang wangys@th.btbu.edu.cn School of Light Industry, Beijing Technology and Business University, 11 Fucheng Road Haidian District, Beijing 100048, China

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/tcyt.

2018). The antimicrobial activity of probiotics occurs through: (1) reduced pH in the lumen due to production of acetic and lactic acids, (2) bacteriocins and reutericyclin accumulation and (3) compounds blocking bacterial adhesion to the epithelial cells and consequently reducing pathogen toxins production (Coman et al., 2014; Tejero-Sariñena, Barlow, Costabile, Gibson, & Rowland, 2012). Also, probiotics are involved in immune modulation, regulation of intestinal health, improved lactose digestion and maintaining bone health (Amorim, Piccoli, & Duarte, 2018; Collins, Kim, McCabe, & Weaver, 2017). They make functional components such as antioxidants and anti-hypertensive γ-aminobutyric acid (GABA) from fruits and vegetable (FV) accessible to human (Su et al., 2015). Whereas, imbalances in the composition and function of the intestinal microbiota have been associated with diseases, including inflammatory bowel disorders, obesity, diarrhea, *diabetes mellitus* type II, colorectal cancer as well as hepatic, neurological, respiratory and cardiovascular diseases (Shokryazdan, Faseleh Jahromi, Liang, & Ho, 2017). Exogenous and endogenous factors including genetic features, immune responses, diet, infection, antibiotics and other drugs use have been reported to influence gut microbiota (Collins et al., 2017; Schmidt, Raes, & Bork, 2018). Henceforth, the microbiota balances need to be improved and sustained.

The abundant source of probiotics can be accessed by spontaneous fermentation of FV in exclusive uncontrollable environmental conditions (Xu, Luo, Bao, Liao, & Wu, 2018). Traditionally fermented dairy products are considered as the main vehicle for probiotics in different regions across the world. This is why several species of LAB, *Lactobacillus* and *Bifidobacterium* were isolated from fermented milk (Fontana et al., 2013; Mishra, Behera, Kar, & Ray, 2018). However, recently consumers awareness on health and nutrition has increased demand and consumption of functional foods (Salvetti & O'Toole, 2017). The trend has created a need for formulation of non-dairy probiotics food from FV. Evidently, dairy products have high cholesterol, lactose and animal proteins that may limit consumption to some population groups (Panghal et al., 2018). Today probiotics products comes in different formulations including fruit juices, fermented vegetables, impregnated FV, infant formulas, condiments, sweeteners, pizza crust and dietary supplements (Champagne, Gomes Da Cruz, & Daga, 2018; Chen et al., 2014; Meybodi, Mortazavian, Sohrabvandi, Cruz, & Mohammadi, 2017). Moreover, exploring the potential of FV prebiotics, probiotics yoghurt are formulated with FV extracts, soluble fibers, inulin and commercial FOS and XOS (Fazilah, Ariff, Khayat, Rios-Solis, & Halim, 2018; Sah, Vasiljevic, McKechnie, & Donkor, 2016; Zhang et al., 2019).

FV potential for probiotics has been studied and reported to be the next category of food to serve as probiotics carrier and a therapeutic microbiome target (Panghal et al., 2018; Septembre-Malaterre, Remize, & Poucheret, 2018). Therefore, this review presents research works on FV probiotics, their isolation and characterization, health benefits, application and related safety issues.

2. Probiotics and prebiotics selection

The selection of probiotics strain from the ecosystems (raw or fermented FV) implies several functional properties that are primarily *in vitro* investigated and proved in animal studies: they must be of human original and a normal inhabitant of the intestine; able to survive in the GIT and resistant to salivary enzymes, gastric acid, pancreatic juice and bile salts; able to colonize and adhere to the GIT epithelium; able to modulate human immune response, decrease incidences of diarrhea and improve the GIT health; maintain the mucosa integrity; are non-pathogenic and non-toxic, produce toxins binding substances and have detoxification activity (Markowiak, Śliżewska, Markowiak, & Śliżewska, 2017). Furthermore, probiotics must be capable of hydrolyzing constituents from FV that cannot be utilized by the host such as the fructans and galactans; fructooligosaccharides (FOS), mannanoligosaccharides (MOS), xylooligosaccharides (XOS), inulin and some antinutritional factors such as tannins (Gibson et al., 2017; Mohanty, Misra, Mohapatra, & Sahu, 2018). They must produce beneficial compounds such as vitamins, antioxidants and antimicrobial substances such as organic acids (lactic and acetic acids), hydrogen peroxide, bacteriocins, aldehydes, acetoin, carbon dioxide, reuterin, reutericyclin, phenolic acids, peptides, short chain fatty acids and competitively exclude pathogens, as presented in Figure 1 (Derrien & van Hylckama Vlieg, 2015).

FV are good source of vitamins, minerals, sugars and other phytonutrients and thus ideal for the microbial growth (Panghal et al., 2018). They are good prebiotics, possess intrinsic properties such as buffering capacity, FOS, inulin, fiber and antinutritional factors (tannins, phenols, phytates as examples) and provide substrates for proliferation of intestinal microbiota

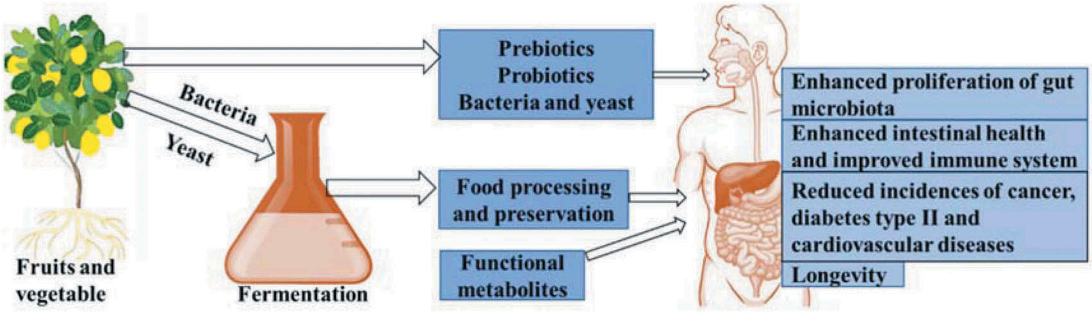

Figure 1. Prebiotics, probiotics and gut microbiota relationship in maintaining human health. Fruits and vegetable can provide prebiotics-probiotics benefits to human through direct consumption of fresh, fermented products and/or functional metabolites in synbiotics food.

Figura 1. Relación entre prebióticos, probióticos y microbiota intestinal para mantener la salud humana. Las frutas y verduras pueden proporcionar beneficios prebióticos-probióticos al ser humano a través del consumo directo de productos frescos fermentados y/o de metabolitos funcionales en los alimentos simbióticos.

(Septembre-Malaterre et al., 2018). Prebiotics are food components that are able to reach the colon undigested and not hydrolyzed in the upper digestive tract, stimulate the growth of microbiota and offers healthy composition for intestinal microflora (Di Gioia & Biavati, 2018). Recently, prebiotics are referred as substrates that are selectively utilized by host microorganisms conferring a health benefit (Gibson et al., 2017). Most prebiotics are non-digestible carbohydrates such as fibers and oligosaccharides, fructans and galactans (Gibson et al., 2017; Hill et al., 2014). In summary, prebiotics should have the following properties: they are neither hydrolyzed nor absorbed and/or can be partially digested in the upper intestine, reaching the colon undigested. They are fermented by intestinal microorganisms and represent selective substrates for one of the beneficial bacteria and must be able to selectively stimulate the growth, metabolism and/or activity of intestinal microflora associated with health, immune or wellbeing (Gibson et al., 2017). Of interest, a review by Schmidt et al. (2018) showed that dietary nutrient contributes only as low as one digit percent variation in microbiota population. The concept describes features of selective utilization by GIT microbiota that prebiotics are differentiated from other undigested nutrients such as vitamins and minerals.

Some of the FV probiotics products are already available in the market, including fermented as well as unfermented FV, organic probiotics drinks and dried fruits enriched with microorganisms (Panghal et al., 2018). FV prebiotics includes aqueous extract of blueberry, China green tea, oolong tea, black and selenium-containing tea, dragon fruits, banana, mulberry leaves and fruit and asparagus among others (Choque Delgado & Tamashiro, 2018; Mohanty et al., 2018; Sun et al., 2018). Some commercial prebiotics are derived or formulated with fiber, inulin and oligofructose, the FOS and galactooligosaccharides (GOS). Whereas, technologies such microencapsulation, immobilization and vacuum impregnation can be used to incorporate probiotics into commercial prebiotics matrices (Mishra et al., 2018).

Combination of prebiotics and probiotics of FV makes it possible to formulate a synbiotics food (Markowiak et al., 2017). Consumption of synbiotics food is more potent to the human health than consumption of probiotics or prebiotics only (McFarland & Goh, 2018). Probiotics and prebiotics components in a single food improve probiotics viability and survival during storage and passage through the GIT (McFarland & Goh, 2018). It allows an efficient implantation of probiotics in the colon due to stimulating effect on the growth and activity of the microorganisms (Sánchez et al., 2017). Some of the prebiotics are able to modify the metabolic profile of probiotics, by supplying selective compounds and branched short chain fatty acids (Fernando et al., 2018; Sánchez et al., 2017). Moreover, prebiotics may provide direct benefits to human health through cholesterol removal, lowering blood sugar, prevention of obesity, relieving constipation and inhibition of pathogens and carcinogens (Mohanty et al., 2018; Zhang et al., 2015). At the same time, they support intestinal and immune system functioning and improves calcium and magnesium absorption (Krupa-Kozak et al., 2017; Mohanty et al., 2018). Generally, fermented FV as prebiotics require few ingredients and minimal processing steps even though some contains only few dominant microbial taxa with remarkably complex population dynamics (Marco et al., 2017).

3. Probiotics isolation and identification

Researches have explored the use of LAB of *Lactobacillus* and *Bifidobacterium* and yeast strains isolated from FV and their addition effect to food systems, aimed at improving quality and functional properties. The main criterion for probiotics isolation is to survive under extreme pH of gastric juice and bile salts in the intestine to reach the target sites in human GIT (Figure 2). Probiotics need to be delivered to the desired sites in an active and viable form for their effectiveness and efficacy. The viability and activity have been reported as probiotics prerequisite for achieving health benefits. The recommended probiotics concentration in food to confer the desired health benefit is at least 10^8 to 10^9 colony forming unit per milliliter (CFU)/ml to ensure a minimum of 10^6 to 10^7 CFU/ml in the colon (Fernando et al., 2018; Shori, 2016, 2017). However, even non-viable culture or heat treated probiotics are proved to have functional properties, bacteriocin accumulation and immune system stimulation effects (Champagne et al., 2018; Lee et al., 2017). For instance, strains of *Oenococcus oeni, Lactobacillus delbrueckii* subsp. *bulgaricus, Streptococcus salivarius* subsp. *thermophilus* and yeast (*Saccharomyces boulardii*) are qualified potential probiotics (Amorim et al., 2018; Foligné et al., 2010). Considering that probiotics are strain-specific and sometimes mixture of strains, culturing techniques are important to produce useful probiotics. Also, isolation and characterization of probiotics from FV need further development.

3.1. Isolation

Isolation is the first requirement for probiotics characterization, health claim submission and marketing. Determination of the genus, species and strain provides useful information for the

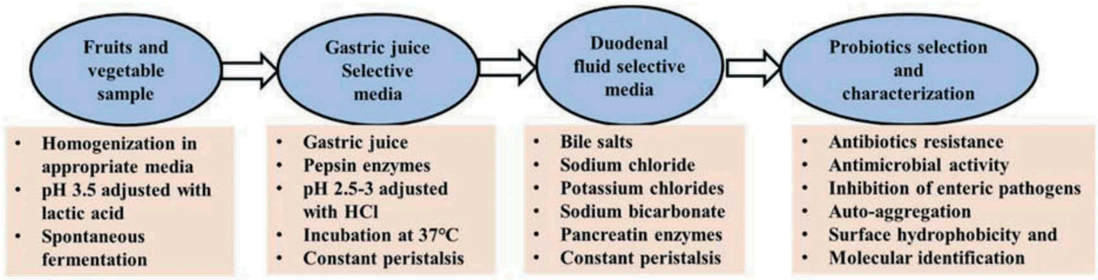

Figure 2. Fruits and vegetable-based probiotics isolation and identification schematic presentation using gastrointestinal tract conditions.

Figura 2. Presentación esquemática del aislamiento e identificación de probióticos a base de frutas y verduras utilizando condiciones similares a las del tracto gastrointestinal.

physiological and metabolic properties of probiotics. Several protocols have been developed for isolation of probiotics from FV so that a probiotics microorganism can resist gastric conditions of pH 2.5–3 and pepsin enzymes, bile salts, pancreatin enzymes and stimulated GIT peristalsis and adapt colon environment (Amorim et al., 2018; Lee et al., 2016). Also, the isolates are qualified for antibiotics resistance, antimicrobial activity and inhibition of enteric pathogens, auto aggregation, cell surface hydrophobicity in animal model and *in vitro* studies. Moreover, for safety reasons, probiotics isolates are tested for production of toxic compounds and hemolytic activity. Various types and forms of fermented FV products are commercially available, including Chinese *hum-coy, inziangsang, sufu, pao-cai, jiang-gua* and *yan-taozih*; Sauerkraut, cucumber pickles and olives in Europe; Turkish *hardaliye*; Korean *kimchi*; Thai *paksian-don*; Malaysian *tempoyak*; Japanese *nazawana-zuke*; Philippine *puto; camuoi* in Vietnam; *kalpi* in Nepal and India; Ethiopian *enjera*; Sudanese *kisra* and; Brazilian cashew apple juice (Panghal et al., 2018; Urbonaviciene, Viskelis, Bartkiene, Juodeikiene, & Vidmantiene, 2015). Different strains of LAB: *Lactobacillus, Bifidobacterium* and yeast have been isolated, characterized and preserved for use as culture in commercial food formulations.

3.2. Identification and characterization

The species level identification is achieved by combination of techniques that includes biochemical information (growth in different media, carbon source, nitrate as well as Gram, catalase, urease and reductase tests), genotype (sequencing of the 16s rRNA gene) and DNA fingerprinting (Repetitive element palindromic PCR, Random Amplified Polymorphic DNA, Restriction Fragment Length Polymorphism (RFLP), PCR-RFLP and Pulse-Field Gel Electrophoresis (PFGE)) (de Melo Pereira, de Oliveira Coelho, Júnior, Thomaz-Soccol, & Soccol, 2018; Lefevre et al., 2017; Mianzhi & Shah, 2017). Some of the probiotics from traditional fermented FV products have been confirmed by various studies (Table 1). However, even with the advanced sequencing technologies some microbes such as *Archaea* could pass unnoticed (Sánchez et al., 2017). The effective probiotics product can only be regarded as safe and useful after the microbiota involved are properly identified, characterized and qualified for human use. It can be summarized that the dominant probiotics in naturally fermented FV are of the genera *Lactobacillus* (Table 1).

4. Health benefits of probiotics

There is a broad association between microbiome and human health status, though no claimed causality. It has been reported that overall microbiome shift, imbalance or reduced diversity are associated and/or predispose individuals to diseases and chronic conditions including inflammatory bowel diseases, cancer, irritable bowel syndrome, allergy, asthma, diabetes, obesity, cardiovascular diseases, neurological diseases and gastrointestinal disorders (Cremon, Barbaro, Ventura, & Barbara, 2018). The imbalances being caused by host genetics and environmental factor such as mode of a neonate delivery, breast-feeding history, diet, infections and use of antibiotics and other drugs (Cenit et al., 2015; Lange, Buerger, Stallmach, & Bruns, 2016; Leiva-Gea et al., 2018). Moreover, lifestyle factors such as smoking, alcohol consumption habit and physical exercises were reported to modulates gut microbiota by changing not only its composition but also functionality (Schmidt et al., 2018; Tao et al., 2019).

Animal models, *in vitro* and human clinical studies have shown effectiveness and potential health benefits of probiotics (Collins et al., 2017). Probiotics have been reported to restore GIT microbiota and provide various health benefits (Table 2). Probiotics can synthesis certain vitamins, notably B group vitamins including biotin, cobalamin, pantothenic acid, pyridoxine, nicotinic acid, thiamine, riboflavin and folate and vitamin K so as to nourish the host (Kaprasob, Kerdchoechuen, Laohakunjit, & Somboonpanyakul, 2018; Rowland et al., 2018). Additionally, probiotics have been associated with improved nutrient bioavailability, lowered blood cholesterol, alleviated lactose intolerance symptoms and reduced incidences of cardiovascular diseases, obesity, *diabetes mellitus* type II, production of anticancer and antimutagenic substances (Lebeer et al., 2018; Shokryazdan et al., 2017). Though, production of immunological, anticancer, bioactive and functional compounds are rarely characterized as strain specific (Hill et al., 2014). For instance, anticancer effect can be achieved by multiple mechanisms: production of compounds with anticarcinogenic activity, reduction of the activity of enzymes involved in the carcinogen formation, binding and degradation of mutagens, reduction of nephrotoxic and immunosuppressive mycotoxins, inhibition of tumor cell proliferation and induced cancer cells apoptosis. Likewise, immunomodulation effect might occur through enhanced production of anti-inflammatory cytokines, immunoglobulins and/or phagocytosis of pathogens (Azad, Sarker, & Wan, 2018; Maldonado Galdeano, Cazorla, Lemme Dumit, Vélez, & Perdigón, 2019).

5. Applications of probiotics

5.1. Probiotics as starter culture in fruits and vegetable products

The potentials of probiotics in fermented FV have been studied and led to the development of starter culture (Xu et al., 2018). Studies have shown successful use of commercial probiotics culture in FV (Bujna, Farkas, Tran, Dam, & Nguyen, 2017). Use of probiotics starter culture for most of the formulations has been a preferred technological approach to minimize variations and to ensure uniformity of the product (Peñas, Martinez-Villaluenga, & Frias, 2017). Some of the probiotics products available in the market contains different formulations of *Lactobacillus acidophilus, L. casei, L. bulgaricus, L. fermentum, L. lactis, L. plantarum, L. reuteri, L. brevis, L. salivarius, L. paracasei, L. rhamnosus, Bifidobacterium longum, B. bifidum, B. infantis, B. breve, B. animalis, B. lactis, Streptococcus thermophilus, Streptococcus* spp., *Enterococcus faecium* and *Saccharomyces cerevisiae* (Dias et al., 2018; Lugli et al., 2019; Morovic, Hibberd, Zabel, Barrangou, & Stahl, 2016). However, *Lactobacillus, Bifidobacterium* and *Saccharomyces* spp. are dominant probiotics in most of commercial products. Due to increased consumer interest in probiotics, products containing a mixed or single culture of live microorganisms are delivered in different formulations within the food matrixes in forms of juice, liquids, suspension, pills, capsules, powder, granules, sachets, chewable bar and so on (Kolaček et al., 2017). Apple, pineapple, cashew apple, orange, banana, black current, cantaloupe, grape, passion fruit, raspberry, mango and blueberry

Table 1. Traditional and emerging fermented fruits and vegetable products and their corresponding probiotics.

Tabla 1. Frutas y verduras fermentadas tradicionales y emergentes y sus probióticos correspondientes.

Products	Main ingredients	Probiotics	References
Burong mustala, Inziangsang, Suan-tsai, Pak-Gard-Dong and Dakguadong	Mustard leaves	*Lactobacillus brevis, L. plantarum, Pediocococcus cerevisiae, Pediococcus pentosaceus* and *Tetragenococcus halophilus*	(Panghal et al., 2018)
Broccoli juice	Broccoli	*Leuconostoc mesenteroides, Weissella* spp., *Enterococcus gallinarum* and *Lactococcus* spp.	(Xu et al., 2018)
Cherries juice	Cherries	*Pediococcus pentosaceus* and *Enterococcus gallinarum*	(Xu et al., 2018)
Cucumbers	Cucumbers, vinegar, salt	*Pediococcus* spp., *Lactobacillus* spp. and *Leuconostoc* spp.	(Zieliński, Surma, & Zielińska, 2017)
Dhamuoi	Cabbage and other vegetables	*Lactobacillus plantarum, Leuconostoc mesenteroides*	(Panghal et al., 2018)
Hardaliye	Red grape juice, black mustard seeds	*Lactobacillus paracasei, L. brevis, L. casei* subsp. *caseipseudoplantarum, L. pontis, L. acetotolerans, L. sanfranciscensis*	(Panghal et al., 2018)
Jiang-gua	Cucumbers, salt, sugar, vinegar and soy sauce	*Leuconostoc lactis, Leoconostoc mesenteroides, Lactobacillus pentosus, Lactobacillus plantarum, Lactobacillus paraplantarum, Lactococcus latis* subsp. *lactis, Weissella hellenica, Weissella cibaria*	(Chen et al., 2012)
Kimchi	Cabbage, radish, spices (garlic, ginger, pepper and onion)	*Lactobacillus plantarum, L. brevis, L. curvatus, L. sakei, L. maltaromicus, L. bavaricus, Weissella confusa, Weissella kimchi, Weissella koreensis, Leuconostoc mesenteroides, Leuconostoc kimchi, Leuconostoc cireum, Leuconostoc gasicomitatum* and *Leuconostoc pseudomesenteroides*	(Le & Yang, 2018)
Pao-cai	Cabbage, celery, cucumber, and radish, ginger, salt, sugar, hot red pepper	*Lactobacillus pentosus, L. plantarum, L. brevis, L. lactis, L. fermentum* and *Leuconostoc mesenteroides*	(Swain et al., 2014)
Pickles	Varieties of fruits and vegetable-cucumbers, mangoes: usually in 10–15% salt NaCl, brine	*Lactobacillus casei, L. planturum, L. rhamnosus, L. Pentosus, L. acidophilus, Pediococcus pentosaceus* and *P. acidilactic*	(Cao et al., 2016; Fan, Breidt, Price, & Pérez-Díaz, 2017)
Radish juice	Radish	*Weissella confusa, Enterococcus durans and Bacillus coagulans*	(Xu et al., 2018)
Salgam	Black carrots, turnip, bulgur flour, sourdough, yeast, salt and water	*Lactobacillus plantarum, L. paracasei, L. fermentum, L. brevis, L. pentosus, L. buchneri, L. helveticus, L. acidophillus, Lactococcus* spp., *Pediococcus* spp., *Leuconosctoc* spp. and *Saccharomyces* spp.	(Coskun, 2017; Ekinci et al., 2016)
Sauerkraut	Cabbage, salt	*Leuconostoc mesenteroides, Lactobacillus brevis* and *L. plantarum*	(Peñas et al., 2017)
Tursu	Cucumbers, cabbage, green tomatoes, green peppers and other vegetables	*Lactobacillus plantarum, L. brevis, Leuconostoc mesenteroides* and *Pediococcus pentosaceus*	(Çetin, 2011)
Wine (red)	Grapes	*Oenococcus oeni, Pediococcus parvulus, P. pentosaceus, Lactobacillus casei* and *L. plantarum*	(García-Ruiz et al., 2014)
Yan-taozih	Peaches, salt, sugar and pickled plums	*Leuconostoc mesenteroides, Lactococcus lactis* subsp. *lactis, L. brevis, Weissella cibaria, W. paramesenteroides, W. minor* and *Enterococcus faecalis*	(Chen et al., 2013)

juices are some of the successful fruit juices used for probiotics delivery (Fernandes Pereira & Rodrigues, 2018).

Conventionally, not all LAB strains from FV can guarantee the same performance during processing. The main criteria used to select them can be categorized as follows:

1. Pro-technological: origin, pathogenicity, toxicity, antibiotics resistance, synthesis of antimicrobial compounds, growth rate and viable cell count, acidification rate, tolerance to low pH and bile salts (Vasiljevic & Shah, 2008).
2. Processing technological: the strain must be genetically stable and survive food processing conditions such as fermentation, oxidative stress and variation in temperatures and pH, phage resistance, viable and stable during storage (Vasiljevic & Shah, 2008).
3. Sensory aspects: synthesis of aroma compounds, change in taste induced by lactic acid accumulation, and other flavor active compounds from proteolytic and lipolytic probiotics enzymes.
4. Nutrition and functional components: synthesis of biogenic compounds, increased antioxidants activity, hydrolyze exo-polysaccharides and tolerant to phenolics, whereas such compounds are abundant in FV (Jiménez-Gómez, García-Fraile, Flores-Félix, & Rivas, 2018; Rowland et al., 2018).

The environmental adaptation of the targeted starter is a prerequisite, which affect all the other potential metabolic features (Tripathi & Giri, 2014). Buffering capacity, pH, concentration of fermentable carbohydrates, species diversity and presence of inhibitory compounds affect the growth and acidification of the probiotics (Shori, 2016). In some foods, even minor alteration to species diversity or numbers can result in inconsistent fermentation, varied metabolites composition and significantly different product in terms of acidity and texture (Marco et al., 2017). Thus, it is worth maintaining ecological environment for improving and maintaining the functional properties and organoleptic quality of probiotics product containing commercial culture.

5.2. Biocontrol, preservation and antagonistic probiotics

Traditionally, LAB have been used in FV processing and preservation to prevent them from spoilage and pathogens proliferation (Swain, Anandharaj, Ray, & Parveen Rani, 2014). Spontaneous FV fermentation produce several beneficial compounds which deserves interest as tools to improve the quality and microbial safety of fermented foods. Some of the probiotics isolate have shown antagonistic towards plant pathogens. Several species of LAB were reported to

Table 2. Example of some probiotics and reported specific benefits to human health.

Tabla 2. Ejemplos de algunos probióticos y beneficios específicos reportados para la salud humana.

Probiotics	Reported specific benefits/antagonistic activity	Reference
Lactobacillus acidophillus	Antimicrobial activity against *Clostridium jejuni* and *Listeria monocytogenes*	(Campana, van Hemert, & Baffone, 2017)
Lactobacillus casei	Antimicrobial activity against *Clostridium sakazakii, Clostridium jejuni* and *Listeria monocytogenes*	(Campana et al., 2017)
Lactobacillus paracasei	Anticancer activity, *E. coli* and *Listeria innocua* inhibition effects	(Tarrah et al., 2019)
Lactobacillus plantarum	Antimicrobial activity against *Streptococcus enteritidis,* Clostridium *sakazakii, Clostridium jejuni, Listeria monocytogenes* and *E. coli*	(Campana et al., 2017)
Lactobacillus lactis	Antimicrobial activity against *Streptococcus enteritidis,* Clostridium *sakazakii, Clostridium jejuni, Listeria monocytogenes* and *E. coli*	(Campana et al., 2017)
Lactobacillus rhamnosus	Antimicrobial activity against *Streptococcus enteritidis, Clostridium sakazakii, Clostridium jejuni, Listeria monocytogenes, E. coli* and *Clostridium difficile*	(Campana et al., 2017; Valdés-Varela, Gueimonde, & Ruas-Madiedo, 2018)
Saccharomyces boulardii	Treatment of antibiotics associated diarrhea as well as by *Clostridium difficile* (traveler's disease)	(Pennacchia et al., 2008; Valdés-Varela et al., 2018)
Weissella cibaria	Anti-inflammatory effect, antimicrobial activity against *Listeria monocytogenes, E. coli* and *Salmonella* spp.	(Le & Yang, 2018)
Weissella koreensis	Anti-obesity, antimicrobial activity against *Listeria monocytogenes, E. coli* and *Salmonella* spp.	(Le & Yang, 2018)
Lactobacillus buchneri	Antimicrobial against *Candida albicans*	(Shokryazdan et al., 2017)
Bifidobacterium animalis	Anti-rotaviral, treatment against antibiotics uses and *Clostridium difficile* related diarrhea. Also improves immune functioning in human	(Miller et al., 2017; Vasiljevic & Shah, 2008)
Bifidobacterium bifidum	Antimicrobial activity against *Clostridium sakazakii, Clostridium jejuni, Listeria monocytogenes* and *E. coli*	(Campana et al., 2017)
Lactobacillus acidophilus and *Bifidobacterium* spp.	Inhibit growth of tumor cell, produce anti-carcinogens and reduces the chances for cancer	(Vasiljevic & Shah, 2008)
Lactobacillus reuteri	Improves immune system	(Indrio et al., 2017)
LAB	Control of blood cholesterol-Hypocholesterolemia-effect and hyperlipidemia, Immune modulation, Effective against *Salmonella enterica* ver. *Typhimurium*, Rota viral infections and *Clostridium difficile* diarrhea.	(Miller et al., 2017; Valdés-Varela et al., 2018; Wang et al., 2014)
Lactobacillus salivarius	Antimicrobial activity against *Listeria monocytogenes, Streptococcus enteritidis, S. mutans, Candida albicans, Clostridium sakazakii* and *C. jejuni*	(Campana et al., 2017; Krzyściak et al., 2017)
Lactobacillus helveticus and *Saccharomyces cerevisiae*	Reduction of hypertension effects	(Hendijani & Akbari, 2018)
Oenococcus oeni	Immune modulation and anti-inflammatory effects	(Foligné et al., 2010)
Lactobacillus acidophilus and *Bifidobacterium longum*	Associated with reduced incidences of colorectal cancer	(Parvez, Malik, Ah Kang, & Kim, 2006)
Bacillus subtilis	Stimulates the immune system, reduce frequency of infections, has antagonistic effect on *H. pylori* infection, also has protective effect on other LAB during food processing, storage and in the GIT	(Lefevre et al., 2017, Lefevre et al., 2015; Pinchuk et al., 2001; Yahav, Berkovich, Ostrov, Reifen, & Shemesh, 2018)
Bacillus clausii	Anti-*Helicobacter pylori* and reduce side effects related to *H. pylori* antibiotics therapy, treatment of acute diarrhea in children and immunomodulating activity	(Ianiro et al., 2018; Nista et al., 2004; Sudha, Jayanthi, Pandey, & Verma, 2019)
Bacillus licheniformis	Prevents insulin resistance, has antibiotics effect against *H. pylori*, reduce the effect of antibiotics use in treatment of diarrhea and can detoxify aflatoxin B1up to 94.7% in food matrixes.	(Elshaghabee, Rokana, Gulhane, Sharma, & Panwar, 2017; Raksha Rao, Vipin, Hariprasad, Anu Appaiah, & Venkateswaran, 2017)

produce a wide array of antagonistic metabolites to FV pathogens as well as spoilage microbes (Choi, Patra, Kim, & Kang, 2018; Gajbhiye & Kapadnis, 2016). This is due to the synthesis of various primary as well as secondary metabolites including organic acids (acetic and lactic acids), carbon dioxide, ethanol, hydrogen peroxide, acetaldehyde, acetoin, antifungal compounds, free fatty acids, phenyl-lactic acids, hydroxyphenyl acids, bacteriocins (nisin), and antibiotics (reutericyclin), all of which may affect broad spectrum of fungi, bacteria, virus, and protozoa (Shokryazdan et al., 2017; Stanton, Ross, Fitzgerald, & Sinderen, 2005).

Recently, use of probiotics in FV preservation has increased as consumer demands for fresh taste and free from chemical preservatives produce. For fresh FV, use of probiotics and bacteriocins do not induce changes as compared to other processing technologies such as heat treatment (Barbosa, Mantovani, & Jain, 2017). Some bacteriocins such as nisin, enterocin, bovicin, bificin and pediocin have proven to be successful in FV preservation against spoilage and pathogenic microorganisms (Barbosa et al., 2017). Bacteriocins are produced *in situ* by probiotics culture incorporated on the surface of fruits or vegetables and/or on the packaging materials (Karunaratne, 2018). With bioprocessing technology advancement, bacteriocins can be added in FV in the purified or semi-purified forms.

Various studies demonstrated successful inhibition or antagonistic effect of bacteriocin against pathogens in juice: enterocin AS-48 reduced viability of *Listeria monocytogenes, Bacillus cereus* and *Staphylococcus aureus*; combination of enterocin AS-48 and nisin inactivated the growth of *Alicylobacillus acidoterrestris* a spoilage bacteria that survives pasteurization temperatures; combination of nisin, acetic acid and sodium lactate was effective against *Listeria monocytogenes*; and nisin-sodium lactate-potassium sorbate formulation effectively inhibited growth of different *Salmonella* spp. (Settanni & Corsetti, 2008). Moreover, enterocin AS-48 inhibited growth of *Pediococcus parvulus, Lactococcus collinoides* and *Lactobacillus diolivorans* strains in most of apple cider tested (Abriouel, Lucas, Ben, Valdivia, & Gálvez, 2010). Iglesias, Abadias, Anguera, Sabata, and Viñas (2017) reported that *Lactobacillus rhamnosus* successfully inhibited the growth of *Salmonella* spp. and *Listeria monocytogenes* in fresh cut pears fruit. Likewise, nisin producing *Lactococcus lactis* strain inoculated in the minimally processed sliced apple enhanced safety of the product by inhibiting the growth of spoilage yeast and *Listeria monocytogenes* (Siroli et al., 2016).

5.3. Probiotics application in cosmetics

Today a large number of probiotics-based cosmetics are used in different forms and numerous products are available in the market. Cosmetics refer to substance or products indented to be rubbed, poured, sprinkled or sprayed on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness or altering appearance (Huang & Tang, 2015). Microbiome such as *Staphylococcus* spp. (*S. epidermis), Propionibacterium* spp. (*P. acnes, P. granulosum* and *P. avidum*) and *Corynebacterium* spp. (*C. simulans, C. tuberculostearium, C. tenuis, C. jeikeium* and *C. xerosis*) are dominant member in the human skin (Byrd, Belkaid, & Segre, 2018; Marini & Krutmann, 2012). Some of the skin pathogens such as *Staphylococcus aureus* are responsible for several skin infection, including impetigo, furuncles, subcutaneous abscesses, skin ulcers and several systemic infections when they get into the blood stream (Ingen-Housz-Oro, Del Giudice, & Chosidow, 2016; Olaniyi, Pozzi, Grimaldi, & Bagnoli, 2016).

It has been suggested that orally administered probiotics exerts effect on the skin via mechanisms initiated in the GIT, most likely due to immune responses such as modulation of specific T-cells and stimulating toll-like receptors (Kober & Bowe, 2015). Some of the products used in beauty industry with probiotics as bioactive ingredients include lotion, anti-aging serum, soap, wipe and aftershave for topical application and ingested probiotics drinks. The most common probiotics claimed on the label are *Lactobacillus* spp. and *Bifidobacterium* spp. (Cinque et al., 2017; Huang & Tang, 2015). *Lactobacillus* spp. probiotics were reported to be effective in managing skin inflammation when administered orally, but their effectiveness and efficacy in children varies. *Staphylococcus epidermis* a commensal skin bacterium is used for treatment of acne related to *P. acne* and other related skin infections (Ouwehand, Lahtinen, & Tiihonen, 2017). *Streptococcus salivarium* spp. *thermophilus* S244 an ingredient in cosmetic formulations has been reported to produce enzymes that reduce skin dryness, loss of tone and water, hence slowing the process of skin aging (Cinque et al., 2017). Animal and human studies had demonstrated that orally administered *Lactobacillus johnsonii* La1 reduces effects of ultra-violet radiation (UV) on immune suppression (Ouwehand et al., 2017).

Some probiotics contributes to increased antioxidants, exopolysaccharides, bioactive proteins, fermented lyases and enzymes activity in modulation of oxidative stress, protecting cells against induced damage by carcinogens and reactive oxygen species generated during body metabolism (Meng et al., 2018). Glutathione, glutathione reductase, s-transferases, glutathione peroxidases, super-peroxide dismutase and catalase are among beneficial probiotics antioxidant enzymes involved in the complex skin antiaging mechanism (Cinque et al., 2017). For instance, *Lactobacillus plantarum* K8 lyases administered orally in human resulted in improved forearm and face skin hydration (Ouwehand et al., 2017). Another skin protection enzyme, sphingomyelinase (SMase) produced by *Streptococcus thermophilus* delivered in exogenous probiotics formulations was reported to improve skin health and effective in treatment of dermatitis and other skin ailments (Lew & Liong, 2013). Moreover, polyphenols and antioxidants from FV as prebiotics composition play roles in skin protection and antiaging mechanisms providing synergetic effect on probiotics (Kwon et al., 2019; Ouwehand et al., 2017).

6. Probiotics safety and regulation

Development and use of probiotics has no universal standard for safety evaluation and regulation and varies from country to country or regional wise (Kolaček et al., 2017; Pineiro & Stanton, 2007). Unlike commercial drugs, probiotics are mostly categorized as food or dietary supplements in the United State of America and Europe, natural health products in Canada, food for specific health use in Japan, thus, comply with significantly less stringent regulations (Kolaček et al., 2017). In China, the Chinese State Food and Drug Administration (SFDA) regulates and oversees functional food and nutraceuticals (Baldi & Arora, 2015; Foligné, Daniel, & Pot, 2013). Probiotics among functional food take a large market share in China influenced by traditional dietary culture and habits along with economic growth.

In the United States of America (U.S.A.), bacteria safe for human consumption are categorized as GRAS (generally recognized as safe) by the Food and Drug Administration (FDA) and such products are not subjected to close monitoring (Degnan, 2008). In Canada, Health Canada accepts 1×10^9 CFU per serving for nonspecific claims as probiotics, which might include the matrix of *Bifidobacterium* and *Lactobacillus* spp. in the formulated probiotics product (Hill et al., 2014).

The European Union, through the European Food Safety Authority (EFSA) proposed an introduction on the Qualified Presumption of Safety (QPS) that could be applicable to select groups of microorganisms for human direct consumption (Salvetti & O'Toole, 2017). The QPS works on taxonomy, characterization, pathogenicity and end user information for conformity to qualify a probiotic. Also, EFSA is responsible for assessment of the probiotics health claim made on food that are submitted by different manufacturers (Salvetti & O'Toole, 2017). The Italian ministry of health regulates the use of probiotics bacteria in food and set the allowable minimum number of viable cell in food per serving at 1×10^9 CFU per day (Hill et al., 2014).

In Japan, probiotics are regulated under Food for Specific Health Use (FOSHU), which permits labelling with health claims on food or ingredients that meet scientific evidence required for safety and efficacy (Amagase, 2008). The FOSHU products are approved by the Japanese Minister of Health, Labor and Welfare (Foligné et al., 2013). The claims are categorized as: special dietary uses, specific health application and food with nutrient function (Kumar et al., 2015). The health claims may cover aspects of cholesterol, triglycerides, blood pressure, blood sugar, bone minerals and dental health. Also, the assessment of novelty is based on the source and the traditional use of foods or food ingredients.

The FAO/WHO has recommended that the following information on the probiotic products should be labelled: genus, species, and strain designation, minimum viable number of each probiotics strain at the end of the shelf life, storage conditions and traceability information such as cooperate contact (Cremon et al., 2018). Although, regulatory standards on probiotics are not established on an international basis, there are no periodic screenings of the product's safety and quality.

While probiotics products are not strictly regulated, a review by Kolaček et al. (2017) presented some aspects of the quality assessment from the U.S.A., Europe, Asia, South Africa and Australia with concern on misinterpretation at the genus, species and strain level and mislabeling. Often, claimed number of viable cells per dose of many products are significantly lower than those on their labels (Chen et al., 2014, 2017). Among major concern are contamination and lower functional properties of probiotics which are influenced by processing, handling and food matrixes.

Some probiotics species might produce problematic effects such as transmission of antibiotics resistance gene to pathogens and production of biogenic amine (Zoumpopoulou et al., 2018). Therefore, the following information are recommended to be disclosed: isolation history or origin, taxonomic identification, absence of virulence, toxicity and chances of antibiotics resistance gene transfer to pathogenic bacteria. Notably, EFSA and GRS in 2007 and 2012, respectively introduced antimicrobial resistance as the safety concern on probiotics consumption due to horizontal gene transfer from beneficial to pathogenic bacteria in the GIT (de Melo Pereira et al., 2018).

7. Conclusions

Probiotics have shown remarkable health benefits to human in a way that their utilization may reduce the use of antibiotics for treatment of diseases such as traveler’s diarrhea reducing the risks of antibiotics resistance and other health problems related to microbiota imbalances. Increase of consumer’s demand for the non-dairy functional probiotics has promoted development of novel FV based probiotics product. Probiotics and their bacteriocin application to FV products as well as biocontrol use to plant pathogens and spoilage microbes provide a promising alternative to chemical additive to control food borne pathogens and spoilage microorganisms. Lastly, it is an urging need to establish international standards to regulate probiotics and prebiotics products and functional health claim on the label to ensure product effectiveness and safety.

Acknowledgments

We thank Dr. Hengming Ke (University of North Carolina at Chapel Hill) for reviewing the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Natural Science Foundation of China [31972127 & 31271944] and the Science and Technology Program of the Beijing Municipal Education Commission [KZ201910011013].

ORCID

Yousheng Wang http://orcid.org/0000-0003-1560-8695

References

Abriouel, H., Lucas, R., Ben, O. N., Valdivia, E., & Gálvez, A. (2010). Potential applications of the cyclic peptide enterocin AS-48 in the preservation of vegetable foods and beverages. *Probiotics and Antimicrobial Proteins*, *2*(2), 77–89. doi:10.1007/s12602-009-9030-y

Amagase, H. (2008). Current marketplace for Probiotics: A Japanese perspective. *Clinical Infectious Diseases*, *46*(s2), S73–S75. doi:10.1086/523338

Amorim, J. C., Piccoli, R. H., & Duarte, W. F. (2018). Probiotic potential of yeasts isolated from pineapple and their use in the elaboration of potentially functional fermented beverages. *Food Research International*, *107*, 518–527. doi:10.1016/J.FOODRES.2018.02.054

Azad, M. A. K., Sarker, M., & Wan, D. (2018). Immunomodulatory effects of probiotics on cytokine profiles. *BioMed Research International*, *2018*, 1–10. doi:10.1155/2018/8063647

Baldi, A., & Arora, M. (2015). Regulatory categories of probiotics across the globe: A review representing existing and recommended categorization. *Indian Journal of Medical Microbiology*, *33*(5), 2. doi:10.4103/0255-0857.150868

Barbosa, A. A. T., Mantovani, H. C., & Jain, S. (2017). Bacteriocins from lactic acid bacteria and their potential in the preservation of fruit products. *Critical Reviews in Biotechnology*, *37*(7), 852–864. doi:10.1080/07388551.2016.1262323

Bujna, E., Farkas, N. A., Tran, A. M., Dam, M. S., & Nguyen, Q. D. (2017). Lactic acid fermentation of apricot juice by mono- and mixed cultures of probiotic Lactobacillus and Bifidobacterium strains. *Food Science and Biotechnology*, *27*(2), 547–554. doi:10.1007/s10068-017-0269-x

Byrd, A. L., Belkaid, Y., & Segre, J. A. (2018). The human skin microbiome. *Nature Reviews Microbiology*, *16*(3), 143–155. doi:10.1038/nrmicro.2017.157

Campana, R., van Hemert, S., & Baffone, W. (2017). Strain-specific probiotic properties of lactic acid bacteria and their interference with human intestinal pathogens invasion. *Gut Pathogens*, *9*(1), 12. doi:10.1186/s13099-017-0162-4

Cao, Z., Pan, H., Tong, H., Gu, D., Li, S., Xu, Y., … Lin, Q. (2016). In vitro evaluation of probiotic potential of Pediococcus pentosaceus L1 isolated from paocai—A Chinese fermented vegetable. *Annals of Microbiology*, *66*(3), 963–971. doi:10.1007/s13213-015-1182-2

Cenit, M., Olivares, M., Codoñer-Franch, P., Sanz, Y., Cenit, M. C., Olivares, M., … Sanz, Y. (2015). Intestinal microbiota and celiac disease: Cause, consequence or co-evolution? *Nutrients*, *7*(8), 6900–6923. doi:10.3390/nu7085314

Çetin, B. (2011). Production of probiotic mixed pickles (Tursu) and microbiological properties. *African Journal of Biotechnology*, *10*(66), 14926–14931. Retrieved from https://www.ajol.info/index.php/ajb/article/view/97233

Champagne, C. P., Gomes Da Cruz, A., & Daga, M. (2018). Strategies to improve the functionality of probiotics in supplements and foods. *Current Opinion in Food Science*, *22*, 160–166. doi:10.1016/J.COFS.2018.04.008

Chen, T., Wu, Q., Li, S., Xiong, S., Jiang, S., Tan, Q., … Wei, H. (2014). Microbiological quality and characteristics of probiotic products in China. *Journal of the Science of Food and Agriculture*, *94*(1), 131–138. doi:10.1002/jsfa.6221

Chen, T., Wu, Q., Zhou, H., Deng, K., Wang, X., Meng, F., … Wei, H. (2017). Assessment of commercial probiotic products in China for labelling accuracy and probiotic characterisation of selected isolates. *International Journal of Dairy Technology*, *70*(1), 119–126. doi:10.1111/1471-0307.12331

Chen, Y., Wu, H., Lo, H., Lin, W., Hsu, W., Lin, C., … Yanagida, F. (2012). Isolation and characterisation of lactic acid bacteria from jiang-gua (fermented cucumbers), a traditional fermented food in Taiwan. *Journal of the Science of Food and Agriculture*, *92*(10), 2069–2075. doi:10.1002/jsfa.5583

Chen, Y., Wu, H., Pan, S., Lin, B., Lin, Y., Tung, W., … Yanagida, F. (2013). Isolation and characterization of lactic acid bacteria from yan-taozih (pickled peaches) in Taiwan. *Annals of Microbiology*, *63*(2), 607–614. doi:10.1007/s13213-012-0510-z

Choi, A.-R., Patra, J. K., Kim, W. J., & Kang, -S.-S. (2018). Antagonistic activities and probiotic potential of lactic acid bacteria derived from a plant-based fermented food. *Frontiers in Microbiology*, *9*, 1963. doi:10.3389/fmicb.2018.01963

Choque Delgado, G. T., & Tamashiro, W. M. D. S. C. (2018). Role of prebiotics in regulation of microbiota and prevention of obesity. *Food Research International*, *113*, 183–188. doi:10.1016/j.foodres.2018.07.013

Cinque, B., Palumbo, P., La Torre, C., Melchiorre, E., Corridoni, D., Miconi, G., … Giuliani, M. (2017). Probiotics in aging skin. In *Textbook of aging skin* (pp. 1315–1327). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-662-47398-6_78

Collins, F. L., Kim, S. M., McCabe, L. R., & Weaver, C. M. (2017). Intestinal microbiota and bone health: The role of prebiotics, probiotics, and diet. In *Bone toxicology* (pp. 417–443). Springer, Cham. doi:10.1007/978-3-319-56192-9_14

Coman, M. M., Verdenelli, M. C., Cecchini, C., Silvi, S., Orpianesi, C., Boyko, N., & Cresci, A. (2014). In vitro evaluation of antimicrobial activity of Lactobacillus rhamnosus IMC 501®, Lactobacillus paracasei IMC 502® and SYNBIO® against pathogens. *Journal of Applied Microbiology*, *117*(2), 518–527. doi:10.1111/jam.12544

Coskun, F. (2017). A traditional Turkish fermented non-alcoholic beverage, "Shalgam.". *Beverages*, *3*(4), 49. doi:10.3390/beverages3040049

Cremon, C., Barbaro, M. R., Ventura, M., & Barbara, G. (2018). Pre- and probiotic overview. *Current Opinion in Pharmacology*, *43*, 87–92. doi:10.1016/J.COPH.2018.08.010

Cutting, S. M. (2011). Bacillus probiotics. *Food Microbiology*, *28*(2), 214–220. doi:10.1016/J.FM.2010.03.007

de Melo Pereira, G. V., de Oliveira Coelho, B., Júnior, A. I. M., Thomaz-Soccol, V., & Soccol, C. R. (2018). How to select a probiotic? A review and update of methods and criteria. *Biotechnology Advances*, *36*, 2060–2076. Retrieved from https://www.sciencedirect.com/science/article/pii/S0734975018301605

Degnan, F. H. (2008). The US food and drug administration and probiotics: Regulatory categorization. *Clinical Infectious Diseases*, *46*(s2), S133–S136. doi:10.1086/523324

Derrien, M., & van Hylckama Vlieg, J. E. T. (2015). Fate, activity, and impact of ingested bacteria within the human gut microbiota. *Trends in Microbiology*, *23*(6), 354–366. doi:10.1016/J.TIM.2015.03.002

Di Gioia, D., & Biavati, B. (2018). Probiotics and prebiotics in animal health and food safety: Conclusive remarks and future perspectives. In *Probiotics and prebiotics in animal health and food safety* (pp. 269–273). Cham: Springer International Publishing. doi:10.1007/978-3-319-71950-4_11

Dias, C. O., Dos Santos Opuski, D. A. J., Pinto, S. S., de Oliveira Santana, F. C., Verruck, S., Müller, C. M. O., … Amboni, R. D. (2018). Development and physico-chemical characterization of microencapsulated bifidobacteria in passion fruit juice: A functional non-dairy product for probiotic delivery. *Food Bioscience*. doi:10.1016/j.fbio.2018.05.006

Doğan, M., Tekiner, İ. H., & DemirkesenBiçak, H. (2019). Probiotics from food products and gastrointestinal health. *Dietary Interventions in Gastrointestinal Diseases*, 169–177. doi:10.1016/B978-0-12-814468-8.00013-2

Ekinci, F. Y., Baser, G. M., Özcan, E., Üstündağ, Ö. G., Korachi, M., Sofu, A., … Chen, C.-Y. O. (2016). Characterization of chemical, biological, and antiproliferative properties of fermented black carrot juice, shalgam. *European Food Research and Technology*, *242*(8), 1355–1368. doi:10.1007/s00217-016-2639-7

Elshaghabee, F. M. F., Rokana, N., Gulhane, R. D., Sharma, C., & Panwar, H. (2017). Bacillus as potential probiotics: Status, concerns, and future perspectives. *Frontiers in Microbiology*, *8*, 1490. doi:10.3389/fmicb.2017.01490

Fan, S., Breidt, F., Price, R., & Pérez-Díaz, I. (2017). Survival and growth of probiotic lactic acid bacteria in refrigerated pickle products. *Journal of Food Science*, *82*(1), 167–173. doi:10.1111/1750-3841.13579

FAO/WHO. (2006). Probiotics in food health and nutritional properties and guidelines for evaluation. In *FAO food and nutrition paper* (Vol. 85, pp. 1–56). Rome:World Health Organization/Food and Agricultre Organization of the United Nations. Retrieved from http://www.fao.org/3/a-a0512e.pdf

Fazilah, N., Ariff, A., Khayat, M., Rios-Solis, L., & Halim, M. (2018). Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt. *Journal of Functional Foods*, *48*, 387–399. doi:10.1016/j.jff.2018.07.039

Fernandes Pereira, A. L., & Rodrigues, S. (2018). Turning fruit juice into probiotic beverages. *Fruit Juices*, 279–287. doi:10.1016/B978-0-12-802230-6.00015-1

Fernando, W. M. A. D. B., Flint, S. H., Ranaweera, K. K. D. S., Bamunuarachchi, A., Johnson, S. K., & Brennan, C. S. (2018). The potential synergistic behaviour of inter- and intra-genus probiotic combinations in the pattern and rate of short chain fatty acids formation during fibre fermentation. *International Journal of Food Sciences and Nutrition*, *69*(2), 144–154. doi:10.1080/09637486.2017.1340932

Floch, M. H. (2018). The role of prebiotics and probiotics in gastrointestinal disease. *Gastroenterology Clinics of North America*, *47*(1), 179–191. doi:10.1016/J.GTC.2017.09.011

Foligné, B., Daniel, C., & Pot, B. (2013). Probiotics from research to market: The possibilities, risks and challenges. *Current Opinion in Microbiology*, *16*(3), 284–292. doi:10.1016/J.MIB.2013.06.008

Foligné, B., Dewulf, J., Breton, J., Claisse, O., Lonvaud-Funel, A., & Pot, B. (2010). Probiotic properties of non-conventional lactic acid bacteria: Immunomodulation by Oenococcus oeni. *International Journal of Food Microbiology*, *140*(2–3), 136–145. doi:10.1016/J.IJFOODMICRO.2010.04.007

Fontana, L., Bermudez-Brito, M., Plaza-Diaz, J., Muñoz-Quezada, S., & Gil, A. (2013). Sources, isolation, characterisation and evaluation of probiotics. *British Journal of Nutrition*, *109*(S2), S35–S50. doi:10.1017/S0007114512004011

Gajbhiye, M. H., & Kapadnis, B. P. (2016). Antifungal-activity-producing lactic acid bacteria as biocontrol agents in plants. *Biocontrol Science and Technology*, *26*(11), 1451–1470. doi:10.1080/09583157.2016.1213793

García-Ruiz, A., González de Llano, D., Esteban-Fernández, A., Requena, T., Bartolomé, B., & Moreno-Arribas, M. V. (2014). Assessment of probiotic properties in lactic acid bacteria isolated from wine. *Food Microbiology*, *44*, 220–225. doi:10.1016/J.FM.2014.06.015

Ghasemian, A., Eslami, M., Shafiei, M., Najafipour, S., & Rajabi, A. (2018). Probiotics and their increasing importance in human health and infection control. *Reviews in Medical Microbiology*, *29*(4), 153–158. doi:10.1097/MRM.0000000000000147

Gibson, G. R., Hutkins, R., Sanders, M. E., Prescott, S. L., Reimer, R. A., Salminen, S. J., … Reid, G. (2017). Expert consensus document: The international scientific association for probiotics and prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature Reviews Gastroenterology & Hepatology*, *14*(8), 491. doi:10.1038/nrgastro.2017.75

Hendijani, F., & Akbari, V. (2018). Probiotic supplementation for management of cardiovascular risk factors in adults with type II diabetes: A systematic review and meta-analysis. *Clinical Nutrition*, *37*(2), 532–541. doi:10.1016/J.CLNU.2017.02.015

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., … Sanders, M. E. (2014). The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature Reviews Gastroenterology & Hepatology*, *11*(8), 506–514. doi:10.1038/nrgastro.2014.66

Huang, M.-C. J., & Tang, J. (2015). Probiotics in personal care products. *Microbiology Discovery*, *3*(1), 5. doi:10.7243/2052-6180-3-5

Ianiro, G., Rizzatti, G., Plomer, M., Lopetuso, L., Scaldaferri, F., Franceschi, F., … Gasbarrini, A. (2018). Bacillus clausii for the treatment of acute diarrhea in children: A systematic review and meta-analysis of randomized controlled trials. *Nutrients*, *10*(8), 1074. doi:10.3390/nu10081074

Iglesias, M. B., Abadias, M., Anguera, M., Sabata, J., & Viñas, I. (2017). Antagonistic effect of probiotic bacteria against foodborne pathogens on fresh-cut pear. *LWT - Food Science and Technology*, *81*, 243–249. doi:10.1016/J.LWT.2017.03.057

Indrio, F., Riezzo, G., Tafuri, S., Ficarella, M., Carlucci, B., Bisceglia, M., … Francavilla, R. (2017). Probiotic supplementation in preterm: Feeding intolerance and hospital cost. *Nutrients*, *9*(9), 965. doi:10.3390/nu9090965

Ingen-Housz-Oro, S., Del Giudice, P., & Chosidow, O. (2016). Common skin bacterial infections. In *Antibiotic and antifungal therapies in dermatology* (pp. 1–20). Cham: Springer International Publishing. doi:10.1007/978-3-319-39424-4_1

Jiménez-Gómez, A., García-Fraile, P., Flores-Félix, J. D., & Rivas, R. (2018). Plants probiotics as a tool to produce highly functional fruits. *Bioactive Molecules in Food*, 1–13. doi:10.1007/978-3-319-54528-8_8-1

Kaprasob, R., Kerdchoechuen, O., Laohakunjit, N., & Somboonpanyakul, P. (2018). B vitamins and prebiotic fructooligosaccharides of cashew apple fermented with probiotic strains Lactobacillus spp., Leuconostoc mesenteroides and Bifidobacterium longum. *Process Biochemistry*, *70*, 9–19. doi:10.1016/J.PROCBIO.2018.04.009

Karunaratne, A. M. (2018). A multifaceted approach to harness probiotics as antagonists on plant based foods, for enhanced benefits to be reaped at a global level. *Journal of the Science of Food and Agriculture*, *98*(14), 5189–5196. doi:10.1002/jsfa.9215

Kober, -M.-M., & Bowe, W. P. (2015). The effect of probiotics on immune regulation, acne, and photoaging. *International Journal of Women's Dermatology*, *1*(2), 85–89. doi:10.1016/J.IJWD.2015.02.001

Kolaček, S., Hojsak, I., Berni Canani, R., Guarino, A., Indrio, F., Orel, R., … Weizman, Z. (2017). Commercial probiotic products: A call for improved quality control. A position paper by the ESPGHAN working group for probiotics and prebiotics. *Journal of Pediatric*

Gastroenterology and Nutrition, *65*(1), 117–124. doi:10.1097/MPG.0000000000001603

Krupa-Kozak, U., Markiewicz, L., Lamparski, G., Juśkiewicz, J., Krupa-Kozak, U., Markiewicz, L. H., … Juśkiewicz, J. (2017). Administration of inulin-supplemented gluten-free diet modified calcium absorption and caecal microbiota in rats in a calcium-dependent manner. *Nutrients*, *9*(7), 702. doi:10.3390/nu9070702

Krzyściak, W., Kościelniak, D., Papież, M., Vyhouskaya, P., Zagórska-Świeży, K., Kołodziej, I., … Jurczak, A. (2017). Effect of a lactobacillus salivarius probiotic on a double-species streptococcus mutans and candida albicans caries biofilm. *Nutrients*, *9*(11), 1242. doi:10.3390/nu9111242

Kumar, H., Salminen, S., Verhagen, H., Rowland, I., Heimbach, J., Bañares, S., … Lalonde, M. (2015). Novel probiotics and prebiotics: Road to the market. *Current Opinion in Biotechnology*, *32*, 99–103. doi:10.1016/J.COPBIO.2014.11.021

Kwon, J. E., Lim, J., Bang, I., Kim, I., Kim, D., & Kang, S. C. (2019). Fermentation product with new equol-producing Lactobacillus paracasei as a probiotic like product candidate for prevention of skin and intestinal disorder. *Journal of the Science of Food and Agriculture*, *99*, 4200–4210. doi:10.1002/jsfa.9648

Lange, K., Buerger, M., Stallmach, A., & Bruns, T. (2016). Effects of antibiotics on gut microbiota. *Digestive Diseases*, *34*(3), 260–268. doi:10.1159/000443360

Le, B., & Yang, S. H. (2018). Isolation of Weissella strains as potent probiotics to improve antioxidant activity of salted squid by fermentation. *Journal of Applied Biological Chemistry*, *61*(1), 93–100. doi:10.3839/jabc.2018.014

Lebeer, S., Bron, P. A., Marco, M. L., Van Pijkeren, J.-P., O'Connell Motherway, M., Hill, C., … Klaenhammer, T. (2018). Identification of probiotic effector molecules: Present state and future perspectives. *Current Opinion in Biotechnology*, *49*, 217–223. doi:10.1016/J.COPBIO.2017.10.007

Lee, A., Lee, Y. J., Yoo, H. J., Kim, M., Chang, Y., Lee, D. S., … Lee, J. H. (2017). Consumption of Dairy Yogurt Containing Lactobacillus paracasei ssp. paracasei, Bifidobacterium animalis ssp. lactis and Heat-Treated Lactobacillus plantarum Improves Immune Function Including Natural Killer Cell Activity. *Nutrients*, *9*(6), 558. doi:10.3390/nu9060558

Lee, K. W., Shim, J. M., Park, S.-K., Heo, H.-J., Kim, H.-J., Ham, K.-S., & Kim, J. H. (2016). Isolation of lactic acid bacteria with probiotic potentials from kimchi, traditional Korean fermented vegetable. *LWT - Food Science and Technology*, *71*, 130–137. doi:10.1016/J.LWT.2016.03.029

Lefevre, M., Racedo, S. M., Denayrolles, M., Ripert, G., Desfougères, T., Lobach, A. R., … Urdaci, M. C. (2017). Safety assessment of Bacillus subtilis CU1 for use as a probiotic in humans. *Regulatory Toxicology and Pharmacology*, *83*, 54–65. doi:10.1016/J.YRTPH.2016.11.010

Lefevre, M., Racedo, S. M., Ripert, G., Housez, B., Cazaubiel, M., Maudet, C., … Urdaci, M. C. (2015). Probiotic strain Bacillus subtilis CU1 stimulates immune system of elderly during common infectious disease period: A randomized, double-blind placebo-controlled study. *Immunity & Ageing*, *12*(1), 24. doi:10.1186/s12979-015-0051-y

Leiva-Gea, I., Sánchez-Alcoholado, L., Martín-Tejedor, B., Castellano-Castillo, D., Moreno-Indias, I., Urda-Cardona, A., … Queipo-Ortuño, M. I. (2018). Gut microbiota differs in composition and functionality between children with Type 1 diabetes and MODY2 and healthy control subjects: A case-control study. *Diabetes Care*, *41*(11), 2385–2395. doi:10.2337/DC18-0253

Lew, L.-C., & Liong, M.-T. (2013). Bioactives from probiotics for dermal health: Functions and benefits. *Journal of Applied Microbiology*, *114*(5), 1241–1253. doi:10.1111/jam.12137

Lugli, G. A., Mangifesta, M., Mancabelli, L., Milani, C., Turroni, F., Viappiani, A., … Ventura, M. (2019). Compositional assessment of bacterial communities in probiotic supplements by means of metagenomic techniques. *International Journal of Food Microbiology*, *294*, 1–9. doi:10.1016/J.IJFOODMICRO.2019.01.011

Maldonado Galdeano, C., Cazorla, S. I., Lemme Dumit, J. M., Vélez, E., & Perdigón, G. (2019). Beneficial effects of probiotic consumption on the immune system. *Annals of Nutrition and Metabolism*, *74*(2), 115–124. doi:10.1159/000496426

Marco, M. L., Heeney, D., Binda, S., Cifelli, C. J., Cotter, P. D., Foligné, B., … Hutkins, R. (2017). Health benefits of fermented foods: Microbiota and beyond. *Current Opinion in Biotechnology*, *44*, 94–102. doi:10.1016/J.COPBIO.2016.11.010

Marini, A., & Krutmann, J. (2012). Pre- and probiotics for human skin. In P. Victor. R (Ed.), *Handbook of diet, nutrition and the skin* (pp. 318–331). Wageningen Academic Publishers. doi:10.3920/978-90-8686-729-5_19

Markowiak, P., Śliżewska, K., Markowiak, P., & Śliżewska, K. (2017). Effects of probiotics, prebiotics, and synbiotics on human health. *Nutrients*, *9*(9), 1021. doi:10.3390/nu9091021

McFarland, L. V., & Goh, S. (2018). Are probiotics and prebiotics effective in the prevention of travellers' diarrhea: A systematic review and meta-analysis. *Travel Medicine and Infectious Disease*, *27*, 11–19. doi:10.1016/J.TMAID.2018.09.007

Meng, X., Li, S., Li, Y., Gan, R.-Y., Li, H.-B., Meng, X., … Li, H.-B. (2018). Gut Microbiota's Relationship with Liver Disease and Role in Hepatoprotection by Dietary Natural Products and Probiotics. *Nutrients*, *10*(10), 1457. doi:10.3390/nu10101457

Meybodi, N. M., Mortazavian, A. M., Sohrabvandi, S., Cruz, A. G. D., & Mohammadi, R. (2017). Probiotic supplements and food products: comparison for different targets. *Applied Food Biotechnology*, *4*(3), 123–132. doi:10.22037/AFB.V4I3.16420

Mianzhi, Y., & Shah, N. P. (2017). Contemporary nucleic acid-based molecular techniques for detection, identification, and characterization of Bifidobacterium. *Critical Reviews in Food Science and Nutrition*, *57*(5), 987–1016. doi:10.1080/10408398.2015.1023761

Miller, L., Lehtoranta, L., Lehtinen, M., Miller, L. E., Lehtoranta, L., & Lehtinen, M. J. (2017). The effect of Bifidobacterium animalis ssp. lactis HN019 on cellular immune function in healthy elderly subjects: Systematic review and meta-analysis. *Nutrients*, *9*(3), 191. doi:10.3390/nu9030191

Mishra, S. S., Behera, P. K., Kar, B., & Ray, R. C. (2018). Advances in probiotics, prebiotics and nutraceuticals. In *Innovations in technologies for fermented food and beverage industries* (pp. 121–141). Cham: Springer International Publishing. doi:10.1007/978-3-319-74820-7_7

Mohanty, D., Misra, S., Mohapatra, S., & Sahu, P. S. (2018). Prebiotics and synbiotics: Recent concepts in nutrition. *Food Bioscience*, *26*, 152–160. doi:10.1016/J.FBIO.2018.10.008

Morovic, W., Hibberd, A. A., Zabel, B., Barrangou, R., & Stahl, B. (2016). Genotyping by PCR and high-throughput sequencing of commercial probiotic products reveals composition biases. *Frontiers in Microbiology*, *7*, 1747. doi:10.3389/fmicb.2016.01747

Nista, E. C., Candelli, M., Cremonini, F., Cazzato, I. A., Zocco, M. A., Franceschi, F., … Gasbarrini, A. (2004). Bacillus clausii therapy to reduce side-effects of anti-Helicobacter pylori treatment: Randomized, double-blind, placebo controlled trial. *Alimentary Pharmacology and Therapeutics*, *20*(10), 1181–1188. doi:10.1111/j.1365-2036.2004.02274.x

Olaniyi, R., Pozzi, C., Grimaldi, L., & Bagnoli, F. (2016). Staphylococcus aureus-associated skin and soft tissue infections: Anatomical localization, epidemiology, therapy and potential prophylaxis. In F. Bagnoli, R. Rappuoli, & G. Grandi (Eds.), *Staphylococcus aureus* (pp. 199–227). Cham: Springer. doi:10.1007/82_2016_32

Ouwehand, A. C., Lahtinen, S., & Tiihonen, K. (2017). The potential of probiotics and prebiotics for skin health. In *Textbook of aging skin* (pp. 1299–1313). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-662-47398-6_77

Panghal, A., Janghu, S., Virkar, K., Gat, Y., Kumar, V., & Chhikara, N. (2018). Potential non-dairy probiotic products – A healthy approach. *Food Bioscience*, *21*, 80–89. doi:10.1016/J.FBIO.2017.12.003

Parvez, S., Malik, K. A., Ah Kang, S., & Kim, H.-Y. (2006). Probiotics and their fermented food products are beneficial for health. *Journal of Applied Microbiology*, *100*(6), 1171–1185. doi:10.1111/j.1365-2672.2006.02963.x

Peñas, E., Martinez-Villaluenga, C., & Frias, J. (2017). Sauerkraut: Production, composition, and health benefits. *Fermented Foods in Health and Disease Prevention*, 557–576. doi:10.1016/B978-0-12-802309-9.00024-8

Pennacchia, C., Blaiotta, G., Pepe, O., & Villani, F. (2008). Isolation of Saccharomyces cerevisiae strains from different food matrices and their preliminary selection for a potential use as probiotics. *Journal of Applied Microbiology*, *105*(6), 1919–1928. doi:10.1111/j.1365-2672.2008.03968.x

Pinchuk, I. V., Bressollier, P., Verneuil, B., Fenet, B., Sorokulova, I. B., Mégraud, F., & Urdaci, M. C. (2001). In vitro anti-helicobacter pyloriactivity of the probiotic strain bacillus subtilis 3 is due to secretion of antibiotics. *Antimicrobial Agents and Chemotherapy*, *45*(11), 3156–3161. doi:10.1128/AAC.45.11.3156-3161.2001

Pineiro, M., & Stanton, C. (2007). Probiotic bacteria: Legislative framework— requirements to evidence basis. *The Journal of Nutrition*, *137* (3), 850S–853S. doi:10.1093/jn/137.3.850S

Raksha Rao, K., Vipin, A. V., Hariprasad, P., Anu Appaiah, K. A., & Venkateswaran, G. (2017). Biological detoxification of aflatoxin B1 by bacillus licheniformis CFR1. *Food Control*, *71*, 234–241. doi:10.1016/J.FOODCONT.2016.06.040

Reid, G. (2016). Probiotics: Definition, scope and mechanisms of action. *Best Practice & Research Clinical Gastroenterology*, *30*(1), 17–25. doi:10.1016/J.BPG.2015.12.001

Rowland, I., Gibson, G., Heinken, A., Scott, K., Swann, J., Thiele, I., & Tuohy, K. (2018). Gut microbiota functions: Metabolism of nutrients and other food components. *European Journal of Nutrition*, *57*(1), 1–24. doi:10.1007/s00394-017-1445-8

Sah, B. N. P., Vasiljevic, T., McKechnie, S., & Donkor, O. N. (2016). Physicochemical, textural and rheological properties of probiotic yogurt fortified with fibre-rich pineapple peel powder during refrigerated storage. *LWT - Food Science and Technology*, *65*, 978–986. doi:10.1016/J.LWT.2015.09.027

Salvetti, E., & O'Toole, P. W. (2017). When regulation challenges innovation: The case of the genus Lactobacillus. *Trends in Food Science & Technology*, *66*, 187–194. doi:10.1016/J.TIFS.2017.05.009

Sánchez, B., Delgado, S., Blanco-Míguez, A., Lourenço, A., Gueimonde, M., & Margolles, A. (2017). Probiotics, gut microbiota, and their influence on host health and disease. *Molecular Nutrition & Food Research*, *61*(1), 1600240. doi:10.1002/mnfr.201600240

Schmidt, T. S. B., Raes, J., & Bork, P. (2018). The human gut microbiome: From association to modulation. *Cell*, *172*(6), 1198–1215. doi:10.1016/J.CELL.2018.02.044

Septembre-Malaterre, A., Remize, F., & Poucheret, P. (2018). Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. *Food Research International*, *104*, 86–99. doi:10.1016/J.FOODRES.2017.09.031

Settanni, L., & Corsetti, A. (2008). Application of bacteriocins in vegetable food biopreservation. *International Journal of Food Microbiology*, *121*(2), 123–138. doi:10.1016/J.IJFOODMICRO.2007.09.001

Shokryazdan, P., Faseleh Jahromi, M., Liang, J. B., & Ho, Y. W. (2017). Probiotics: From Isolation to Application. *Journal of the American College of Nutrition*, *36*(8), 666–676. doi:10.1080/07315724.2017.1337529

Shori, A. B. (2016). Influence of food matrix on the viability of probiotic bacteria: A review based on dairy and non-dairy beverages. *Food Bioscience*, *13*, 1–8. doi:10.1016/J.FBIO.2015.11.001

Shori, A. B. (2017). Microencapsulation improved probiotics survival during gastric transit. *HAYATI Journal of Biosciences*, *24*(1), 1–5. doi:10.1016/J.HJB.2016.12.008

Siroli, L., Patrignani, F., Serrazanetti, D. I., Vannini, L., Salvetti, E., Torriani, S., … Lanciotti, R. (2016). Use of a nisin-producing Lactococcus lactis strain, combined with natural antimicrobials, to improve the safety and shelf-life of minimally processed sliced apples. *Food Microbiology*, *54*, 11–19. doi:10.1016/J.FM.2015.11.004

Stanton, C., Ross, R. P., Fitzgerald, G. F., & Sinderen, D. V. (2005). Fermented functional foods based on probiotics and their biogenic metabolites. *Current Opinion in Biotechnology*, *16*(2), 198–203. doi:10.1016/J.COPBIO.2005.02.008

Su, J., Wang, T., Li, -Y.-Y., Li, J., Zhang, Y., Wang, Y., … Li, H. (2015). Antioxidant properties of wine lactic acid bacteria: Oenococcus oeni. *Applied Microbiology and Biotechnology*, *99*(12), 5189–5202. doi:10.1007/s00253-015-6425-4

Sudha, M. R., Jayanthi, N., Pandey, D. C., & Verma, A. K. (2019). Bacillus clausii UBBC-07 reduces severity of diarrhoea in children under 5 years of age: A double blind placebo controlled study. *Beneficial Microbes*, 1–6. doi:10.3920/BM2018.0094

Sun, H., Chen, Y., Cheng, M., Zhang, X., Zheng, X., & Zhang, Z. (2018). The modulatory effect of polyphenols from green tea, oolong tea and black tea on human intestinal microbiota in vitro. *Journal of Food Science and Technology*, *55*(1), 399–407. doi:10.1007/s13197-017-2951-7

Swain, M. R., Anandharaj, M., Ray, R. C., & Parveen Rani, R. (2014). Fermented fruits and vegetables of Asia: A potential source of probiotics. *Biotechnology Research International*, *2014*, 250424. doi:10.1155/2014/250424

Syngai, G. G., Gopi, R., Bharali, R., Dey, S., Lakshmanan, G. M. A., & Ahmed, G. (2016). Probiotics - the versatile functional food ingredients. *Journal of Food Science and Technology*, *53*(2), 921–933. doi:10.1007/s13197-015-2011-0

Tamang, J. P., Shin, D.-H., Jung, S.-J., & Chae, S.-W. (2016). Functional properties of microorganisms in fermented foods. *Frontiers in Microbiology*, *7*, 578. doi:10.3389/fmicb.2016.00578

Tao, J., Li, S., Gan, R.-Y., Zhao, C.-N., Meng, X., & Li, H.-B. (2019). Targeting gut microbiota with dietary components on cancer: Effects and potential mechanisms of action. *Critical Reviews in Food Science and Nutrition*, 1–13. doi:10.1080/10408398.2018.1555789

Tarrah, A., Da Silva Duarte, V., de Castilhos, J., Pakroo, S., Junior, W., Luchese, R., … Giacomini, A. (2019). Probiotic potential and biofilm inhibitory activity of Lactobacillus casei group strains isolated from infant feces. *Journal of Functional Foods*, *54*, 489–497. doi:10.1016/j.jff.2019.02.004

Tejero-Sariñena, S., Barlow, J., Costabile, A., Gibson, G. R., & Rowland, I. (2012). In vitro evaluation of the antimicrobial activity of a range of probiotics against pathogens: Evidence for the effects of organic acids. *Anaerobe*, *18*(5), 530–538. doi:10.1016/J.ANAEROBE.2012.08.004

Tripathi, M. K., & Giri, S. K. (2014). Probiotic functional foods: Survival of probiotics during processing and storage. *Journal of Functional Foods*, *9*, 225–241. doi:10.1016/J.JFF.2014.04.030

Urbonaviciene, D., Viskelis, P., Bartkiene, E., Juodeikiene, G., & Vidmantiene, D. (2015). The use of lactic acid bacteria in the fermentation of fruits and vegetables — technological and functional properties. In *Biotechnology*. InTech. doi:10.5772/59938

Valdés-Varela, L., Gueimonde, M., & Ruas-Madiedo, P. (2018). Probiotics for prevention and treatment of clostridium difficile infection. In *Updates on clostridium difficile in Europe* (pp. 161–176). Cham: Springer. doi:10.1007/978-3-319-72799-8_10

Vasiljevic, T., & Shah, N. P. (2008). Probiotics—From Metchnikoff to bioactives. *International Dairy Journal*, *18*(7), 714–728. doi:10.1016/J.IDAIRYJ.2008.03.004

Wang, S. C., Chang, C. K., Chan, S. C., Shieh, J. S., Chiu, C. K., & Duh, P.-D. (2014). Effects of lactic acid bacteria isolated from fermented mustard on lowering cholesterol. *Asian Pacific Journal of Tropical Biomedicine*, *4*(7), 523–528. doi:10.12980/APJTB.4.201414B54

Xu, X., Luo, D., Bao, Y., Liao, X., & Wu, J. (2018). Characterization of diversity and probiotic efficiency of the autochthonous lactic acid bacteria in the fermentation of selected raw fruit and vegetable juices. *Frontiers in Microbiology*, *9*, 2539. doi:10.3389/fmicb.2018.02539

Yahav, S., Berkovich, Z., Ostrov, I., Reifen, R., & Shemesh, M. (2018). Encapsulation of beneficial probiotic bacteria in extracellular matrix from biofilm-forming bacillus subtilis. *Artificial Cells, Nanomedicine, and Biotechnology*, *46*(sup2), 974–982. doi:10.1080/21691401.2018.1476373

Zhang, T., Jeong, C. H., Cheng, W. N., Bae, H., Seo, H. G., Petriello, M. C., & Han, S. G. (2019). Moringa extract enhances the fermentative, textural, and bioactive properties of yogurt. *LWT*, *101*, 276–284. doi:10.1016/J.LWT.2018.11.010

Zhang, Y.-J., Li, S., Gan, R.-Y., Zhou, T., Xu, D.-P., Li, H.-B., … Li, H.-B. (2015). Impacts of gut bacteria on human health and diseases. *International Journal of Molecular Sciences*, *16*(12), 7493–7519. doi:10.3390/ijms16047493

Zieliński, H., Surma, M., & Zielińska, D. (2017). The naturally fermented sour pickled cucumbers. *Fermented Foods in Health and Disease Prevention*, 503–516. doi:10.1016/B978-0-12-802309-9.00021-2

Zoumpopoulou, G., Kazou, M., Alexandraki, V., Angelopoulou, A., Papadimitriou, K., Pot, B., & Tsakalidou, E. (2018). Probiotics and prebiotics: An overview on recent trends. In *Probiotics and prebiotics in animal health and food safety* (pp. 1–34). Cham: Springer International Publishing. doi:10.1007/978-3-319-71950-4_1