Yogurt with Incorporated Probiotics

Subjects: Food Science & Technology | Agriculture, Dairy & Animal Science | Microbiology
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Probiotics are commonly added to yogurt to provide many health benefits for the consumer. A description is provided for some commonly used probiotics in yogurt. A GRAS (generally recognized as safe) list of probiotic bacteria that can be added to yogurt or similar types of products is provided. Additionally, prebiotics, synbiotics (combination of prebiotics and probiotics), postbiotics, paraprobiotics, and psychobiotics can be added to yogurt. Probiotic yogurt can come in various forms in addition to spoonable yogurt, and yogurt can be used as an ingredient in other food products. Many useful functional ingredients can be applied to probiotic yogurt. The safety of probiotics must be addressed, especially for critically ill patients and other susceptible populations.

Keywords: probiotic ; fermented ; yogurt ; health

1. History of Discovery and Definitions of Probiotics

Experiments for studying effects of bacteria on treating health problems and promoting good health have been performed for a long time. Theodor Escherich has been credited as the first pediatric infectious disease physician and described *Bacterium coli commune* (now referred to as *Escherichia coli*) in 1886 [1]. While working under Theodor Escherich, Dr. Józef Brudziński treated infants for acute infectious diarrhea by using a *Bacillus lactis aërogenes* suspension described in publications from 1899 [2][3]. Although Élie Metchnikoff [4] believed that intestinal putrefaction can shorten life, he noted the work of Dr. Brudziński and similar work by Dr. Henry Tissier and recommended people “to absorb large quantities of microbes”. He believed that lactic bacteria can fight against intestinal putrefaction. He also wrote that Stamen Grigoroff observed many centenarians in Bulgaria, which is a region where yahourth (yogurt) was commonly consumed [4]. The fact that diet affects the types of bacteria that develops within the intestinal tract was first clearly established by Herter and Kendall in 1910, but suggested as early as 1886 by Escherich and Hirschler [5].

Many of the starter cultures and probiotics now used in yogurt making were first described in the late 1800s or early 1900s. The name “*Streptococcos*” was first used in 1874 by Albert Theodor Billroth [6]. *Streptococcus thermophilus* (later reclassified as *Streptococcus salivarius* subsp. *thermophilus* by Farrow and Collins in 1984 [7] but revived back to *Streptococcus thermophilus* by Schleifer et al. in 1991 [8]) was described by S. Orla-Jensen in 1919 [9]. In 1901, Martinus Beijerinck proposed the genus *Lactobacillus* to include Gram-positive, fermentative, facultatively anaerobic, non-sporeforming bacteria [10]. Stamen Grigoroff discovered Bulgarian bacillus (now *Lactobacillus delbrueckii* ssp. *bulgaricus*) in 1905 [11]. *Lactobacillus acidophilus* (originally called *Bacillus acidophilus*) was described by Ernst Moro in 1900 [12]. In 1899 and 1900, Henry Tissier first described *Bacillus bifidus communis*, later referred to as *Lactobacillus bifidus* and now referred to as *Bifidobacterium* [13]. He found that *Bifidobacteria* was the main type of bacteria comprising the gut microflora of breast-fed babies and *Bifidobacteria* could treat acute gastroenteritis [11].

Dr. Isaac Carosso recommended to his patients who suffered from gastrointestinal problems to consume yogurt. Afterwards, he started producing yogurt and founded the Danone Company in 1919 [11].

The term “probiotic” (meaning “for life”) originated in 1953 from Werner Kollath to mean “active substances that are essential for a healthy development of life” [14]. Lilly and Stillwell [15] used the term probiotic as “substances secreted by one organism which stimulate the growth of another” in 1965. Parker [16] described probiotics as “organisms and substances which contribute to intestinal microbial balance” in 1974. Fuller [17] defined probiotics as “A live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance” in 1989. A panel from the International Scientific Association for Probiotics and Prebiotics defined probiotic as “live microorganisms that, when administered in adequate amounts, confer a health benefit on the host” in 2014 [18].

2. Gut Microbiome, Inflammation, and Health Benefits Provided by

Probiotics

The human gut microbiome (also known as microbiota or microflora) consists of bacteria (predominantly obligate anaerobes), archaea, fungi, and protists and functions by metabolizing nutrients (by converting indigestible carbohydrates into short-chain fatty acids) for the host, maintaining the gut mucosal barrier, modifying the immune system, inhibiting pathogens, and even affecting brain activities. Most of these bacteria belong to the Firmicutes and Bacteroidetes phyla with fewer bacteria belonging to Actinobacteria, Proteobacteria, Fusobacteria, and Verrucomicrobia phyla. Firmicutes bacteria are Gram-positive and are involved in short chain fatty acid synthesis and in hunger and satiety regulation [19]. Bacteroidetes bacteria are Gram-negative and are involved with enhancing immune reactions and inflammation. A loss of a balanced ratio between Firmicutes and Bacteroidetes leads to dysbiosis (lack of normal intestinal homeostasis), obesity (increased Firmicutes to Bacteroidetes ratio), inflammatory bowel disease (decreased Firmicutes to Bacteroidetes ratio), and other diseases [19]. The Firmicutes phylum includes *Clostridium* (95% of this phylum), *Lactobacillus*, *Bacillus*, *Enterococcus*, and *Ruminicoccus* genera, and the Bacteroidetes phylum consists of *Bacteroides* and *Prevotella* genera [20]. Although early studies estimated the microorganism population as more than 100 trillion and number of human cells as around 10 trillion, more recent estimates state a ratio of 1.3 bacteria cells to each human cell [21]. The microbiome produces a wide variety of metabolites and can account for some of the variation in plasma metabolites between individuals [22]. The composition of the gut microbiome and gut-derived metabolites are associated with the occurrence of a wide variety of chronic diseases [23]. In addition, the effect that diet and exercise have on cognition is affected by the gut microbiome [24]. Furthermore, the microbiota was found to affect social behavior in zebrafish during early neurodevelopment [25]. However, the gut microflora can be affected by various factors including consumption of fermented dairy products [26][27][28].

While acute (high-grade but short-term) inflammation is needed for healing, trigger removal, and tissue repair, systemic chronic (low-grade but persistent) inflammation can lead to a wide variety of adverse health conditions including metabolic syndrome (hypertension, hyperglycemia, and dyslipidemia), type 2 diabetes, nonalcoholic fatty liver disease, cardiovascular disease, chronic kidney disease, multiple cancer types, depression, neurodegenerative and autoimmune diseases, osteoporosis, and sarcopenia [29]. Probiotics, along with prebiotics, resistant starch, and resistant proteins, can decrease chronic low-grade inflammation by producing short-chain fatty acids (acetate, propionate, and butyrate), improving phagocytic activity, and reducing pro-inflammatory cytokine production to potentially promote healthy aging [30].

Probiotics provide many health benefits. Some of these health benefits provided by probiotics, postbiotics, and paraprobiotics (to be discussed later) with either mixed or strong evidence for effectiveness in clinical trials are summarized in **Table 1** [31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66][67][68][69][70][71][72][73][74][75][76][77][78][79][80][81][82][83][84][85][86][87][88][89][90][91][92][93][94][95][96][97][98][99][100][101][102][103][104][105][106][107][108][109][110][111][112][113][114][115][116][117][118][119][120][121][122][123][124][125][126][127][128][129][130][131]. Because of the complexity involved in being consistent when evaluating the strength of the evidence for the effectiveness of probiotics in preventing or treating each of these adverse health conditions or providing the health benefits, no attempt was made for this evaluation. The efficacy of probiotics in controlling Crohn's disease usually could not be shown [132]. More details about the health benefits provided by yogurt and probiotic fermented milks are provided by Sakandar and Zhang [133], and Hadjimbei et al. [134].

Table 1. Some health benefits for which probiotics, postbiotics, and paraprobiotics have shown a mixed to favorable result in an original study or in a meta-analysis. Due to the difficulty of being consistent involved in evaluating the strength of the evidence for the effectiveness of probiotics in preventing or treating each of these health conditions, no attempt was made for the evaluation of effectiveness for the probiotics listed in this table.

Health Condition	Probiotic	Original Article or Review Paper	Reference
Periodontal disease		**Review**	[31]
Bacterial tonsillitis	***Streptococcus salivarius*** **BIO5**	**Original**	[135]
Anti-inflammatory and antibiofilm activities against oral pathogens	***Enterococcus faecalis*** **M157 in fermented whey**	**Original**	[32]
Lactose intolerance		**Review**	[33]
Galactosemia	**Galactose positive *S. thermophilus* NCDC 659 (AJM), 660 (JMI), and 661 (KM3)**	**Original**	[34]
Short-chain fatty acid production	**VSL#3 [1]**	**Original**	[35]

Health Condition	Probiotic	Original Article or Review Paper	Reference
Vitamin production		Review	[36]
Gamma-aminobutyric acid production	*L. plantarum* K16	Original	[37]
Protection against foodborne illness		Review	[38]
Colonization of *Campylobacter*	*L. plantarum* LPS	Original	[39]
Anti-listerial activity	Postbiotics of *L. acidophilus* LA5, *L. casei* 431, and *L. salivarius* Ls-BU2	Original	[40]
Antimicrobial therapy		Review	[41]
Gut microbiome development in very preterm infants	Either *B. bifidum* and *L. acidophilus* or *B. bifidum* and *B. longum* subsp. *infantis* and *L. acidophilus*	Original	[42]
Healthy microbiome	*B. subtilis* DE111	Original	[43]
Restoration of microbiome after antibiotic treatment	*L. acidophilus* and *B. bifidum*	Original	[44]
Improve microbiome in cirrhosis patients	Multispecies probiotics	Original	[45]
Modulate gut microbiota and reduce exposure to uremic toxins in hemodialysis patients	Bifico (*B. longum* NQ1501, *L. acidophilus* YIT2004, and *E. faecalis* YIT0072)	Original	[46]
Gut bacterial diversity	*Bacillus coagulans* GBI-30 6086	Original	[47]
Leaky gut	Probiotic cocktail of 5 *Lactobacilli* and 5 *Enterococci* strains	Original	[48]
Improve Gut Epithelial Barrier	*S. thermophilus* BGKMJ1-36 and *L. bulgaricus* BGVLJ1-21	Original	[49]
Antioxidative activity		Review	[50]
Antioxidant activity and intestinal permeability in cancer carcinogenesis	VSL#3 [1]	Original	[51]
Oxidative and inflammatory stress reduction	*L. plantarum* S1 (viable and heat-killed cells and metabolites) from fermented whey	Original	[52]
Immunity		Review	[53]
Exopolysaccharide production for immunomodulatory, antimicrobial, antioxidant, and anticancer activities	*Lactobacillus*	Review	[54]
Highly symptomatic celiac disease	*Bifidobacterium infantis* NLS super strain	Original	[55]
Viral infections	Various probiotics and paraprobiotics	Review	[56]
Possible inhibition of HIV transmission and replication	Engineered *L. rhamnosus* GG and GR-1	Original	[57]
Diarrhea in HIV/AIDS patients	Probiotic yogurt with *L. rhamnosus* GR-1 and *L. reuteri* RC-14	Original	[58]
Antibiotic-associated diarrhea	*B. animalis* subsp. *lactis* XLTG11	Original	[59]
Chemotherapy-induced diarrhea in lung cancer patients	*Clostridium butyricum*	Original	[60]
Enteral-tube-feeding diarrhea [2]		Review	[61]
Childhood rotavirus infections		Review	[62]
Acute pediatric diarrhea		Review	[63]
Travelers diarrhea	*Lactobacillus* GG	Original	[64]
	L. acidophilus and B. *bifidum*	Original	[65]

Health Condition	Probiotic	Original Article or Review Paper	Reference
Clostridioides difficile diarrhea	*L. rhamnosus* GG	Original	[66]
Helicobacter pylori infection	*Limosilactobacillus fermentum* UCO-979C	Original	[67]
Constipation	*L. acidophilus* LA11-Onlly, *L. rhamnosus* LR22, *L. reuteri* LE16, *L. plantarum* LP-Onlly, and *B. animalis* subsp. *lactis* BI516	Original	[68]
	L. rhamnosus LR-168, *L. acidophilus* LA-99, and *B. animalis* BB-115	Original	[69]
Irritable bowel syndrome		Review	[70]
Necrotizing enterocolitis	*B. longum* subsp. *infantis*	Original	[71]
Ulcerative colitis		Review	[72]
		Review	[73]
Hospital stay for acute pancreatitis		Review	[74]
Colorectal cancer		Review	[75]
Gastrointestinal cancer		Review	[76]
Liver and breast cancer	*Streptococcus salivarius* BP8, BP156, and BP160	Original	[77]
Breast cancer		Review	[78][79]
Prostate cancer	Whey beverages with *L. acidophilus* La-05, *L. acidophilus* La-03, *L. casei-01*, and *B. animalis* Bb-12	Original	[80]
Cervical cancer		Review	[81]
Polycystic ovary syndrome		Review	[82]
Vaginosis	*Lactobacillus*	Original	[83]
Antimicrobial activity (hydrogen peroxide, bacteriocins, and lactic acid production) for vaginal health	*Lactobacillus crispatus*	Review	[84]
Inhibit sperm activity	*Lactobacillus crispatus*	Original	[85]
Male fertility disorders		Review	[86]
Bladder cancer		Review	[87]
Bladder diseases (bladder cancer, interstitial cystitis, and overactive bladder)		Review	[88]
Reduce exposure to uremic toxins in hemodialysis patients	Bifico (*B. longum* NQ1501, *L. acidophilus* YIT2004, and *E. faecalis* YIT0072)	Original	[46]
Pediatric urinary tract infection recurrence	*L. acidophilus, L. rhamnosus, B. bifidum*, and *B. lactis*	Original	[89]
Urinary excretion of oxalate (risk factor for renal stones)	*L. acidophilus*, *L. brevis*, *L. plantarum*, *B. infantis*, and *S. thermophilus*	Original	[90]
Idiopathic nephrotic syndrome	*Clostridium butyricum*	Original	[91]
Lung metastasis of melanoma cells	VSL#3 [1]	Original	[35]
Respiratory tract infection		Review	[92]
Influenza A virus	*L. mucosae* 1025 and *B. breve* CCFM1026	Original	[93]
COVID-19	Probiotics and their metabolites	Review	[94]
Ventilator-associated pneumonia in critically ill patients		Review	[95]

Health Condition	Probiotic	Original Article or Review Paper	Reference
Allergic rhinitis	*Bifidobacterium* mixture	Review	[96]
Respiratory allergy	Commercial probiotic fermented milk	Original	[97]
Asthma	*L. paracasei* K47	Original	[98]
Cystic fibrosis		Review	[99]
Atopic dermatitis		Review	[100]
Skin disorders (atopic dermatitis, psoriasis, rosacea, and acne vulgaris)		Review	[101]
Skin health	*L. reuteri* ATCC 6475	Original	[102]
Dry eye	*L. plantarum* NK151 and *B. bifidum* NK175	Original	[103]
Vernal keratoconjunctivitis	*L. acidophilus* eye drops	Original	[104]
Rheumatoid arthritis [2]		Review	[105][106]
Recovery from bone fractures	*L. casei* Shirota	Original	[107]
Pain relief after rib fracture	*L. casei* Shirota	Original	[108]
Mineral absorption and bone health	*L. rhamnosus* HN001	Original	[109]
Calcium absorption	*L. rhamnosus* GG *	Original	[110]
Iron absorption		Review	[111]
Blood lipids	*B. subtilis* DE111		[112]
Fasting glucose and insulin levels		Review	[113]
Diabetes (blood pressure, fasting blood sugar, cholesterol, triglyceride, hemoglobin A1c, high sensitive C-reactive protein)	Probiotic yogurt	Original	[114]
Serum triglyceride and glucose	*Bacillus coagulans* GBI-30 6086	Original	[47]
Atherosclerosis (lesion formation, dyslipidemia, endothelial dysfunction, inflammation, hypertension and hyperglycemia, and TMAO (trimethylamine *N*-oxide))		Review	[115]
Infantile colic	*B. breve* CECT7263	Original	[116]
Obesity	*L. reuteri* ATCC 6475	Original	[117]
		Review	[118]
Liver fibrosis	*L. paracasei*, *L. casei*, and *Weissella confusa*	Original	[119]
Non-alcoholic fatty liver disease		Review	[120]
Hyperuricemia		Review	[121]
Phenylketonuria	Genetically engineered probiotics	Review	[122]
Exercise performance and decrease fatigue	*L. salivarius* subsp. *salicinius* SA-03	Original	[123]
Sleep		Review	[124]
Depression and anxiety		Review	[125]
Anxiety		Original	[126]
Serotonin biosynthesis from tryptophan	*L. plantarum* LRCC5314	Original	[127]
Mood		Original	[128]

Health Condition	Probiotic	Original Article or Review Paper	Reference
Memory and learning	***L. paracasei* ssp. *paracasei* BCRC 12188, *L. plantarum* BCRC 12251, and *S. thermophilus* BCRC 13869**	**Original**	[129]
Age related dementia		**Review**	[130]
Autism		**Review**	[131]

[1] VSL#3 includes *B. breve*, *B. infantis*, *B. longum*, *L. acidophilus*, *L. bulgaricus*, *L. casei*, *L. plantarum*, and *S. thermophilus*. [2] Mixed results. * Inulin was also included in the treatment which may have contributed to the favorable results.

Different strains of bacteria provide their health benefits by different mechanisms [136], and knowledge of these mechanisms can help in probiotic selection and modification for effectively treating disease. Four main mechanisms by which probiotics confer health benefits include potential pathogen interference, barrier function improvement, immunomodulation, and neurotransmitter production [137]. Pathogen interference mechanisms include production of antimicrobial compounds including bacteriocins and defensins, competition with pathogens, inhibition of adherence of pathogens, and luminal pH reduction [136]. Probiotics such as *L. rhamnosus* can be bioengineered for an alternative method for pathogen inhibition within the field known as pathobiotechnology [138].

Gut microbiomes vary from person to person [20]. Individuals vary in the ability of which consumed probiotics, such as in a fermented milk product, are able to modify the composition of the autochthonous gut microflora, suggesting that a tailored diet may be needed for individuals that are on a beneficial microbial based therapy and have a resistant gut microbiota [139]. Veiga et al. [140] predicts that many people will have their genome sequenced in the future that will allow them to tailor specific probiotics (referred to as precision probiotics) to their unique human-microbiome symbiosis to optimize their microbiome-centered nutrition and preventative health care. Perhaps in the future, yogurt could be a carrier for these precision probiotics.

3. Use of Probiotic Yogurt as an Ingredient

Probiotic yogurt can be used as an ingredient in the production of other products. Bite sized refrigerated yogurt that can be eaten using fingers can be prepared by coating frozen yogurt portions (possibly containing probiotics) with two layers of fat-based coating [141]. The second layer of this fat coating is applied before allowing the frozen yogurt to thaw, and this second layer may contain particulate inclusions [141]. A snack bar coated with a yogurt containing probiotics (*L. acidophilus* or *B. lactis* or both) and incorporating waxy grains held together by an inulin binder has been patented [142]. A shelf-stable fruit snack that contains an outer layer that could consist of yogurt containing probiotic cultures has been patented [143]. Gutknecht and Ovitt [144] patented low-fat yogurt cheese consisting of 15% to 75% cream cheese, 10% to 40% yogurt incorporating *L. acidophilus*, *Bifidobacterium*, or *L. paracasei* subsp. *casei* in addition to yogurt starter cultures, and 15% to 45% milk protein. Freeze dried yogurt that may contain probiotic cultures is an ingredient in a dry mix food product that also contains other food ingredients (whole grain, fruits, nuts, granola, etc.), and this dry mix can be hydrated to form a thick texture similar to yogurt within 3 min [145]. A shelf-stable light and crunchy yogurt crisp, a snack food, is made from a viscoelastic dough that contains dehydrated yogurt and may contain probiotics, either in the spore form or microencapsulated form [146].

4. Useful Functional Ingredients in Probiotic Yogurt

Many ingredients have successfully been added to probiotic yogurt. Some of these useful functional ingredients are listed in **Table 2**. These functional ingredients include grains, seeds, flours, fibers, fruits, vegetables, a berry, a nut, juices, spices, essential oils, bee products, and a cyanobacterium.

Table 2. Some of the useful functional ingredients that have been incorporated into probiotic yogurt including their concentration and effect on the properties of the resulting yogurt.

Functional Ingredient Category and Ingredient within category.	Concentration	Effect on Properties	Ref.
Grain, seed, and flour			
Aqueous fennel extract	2, 4, and 6%	Reconstituting whole milk powder into aqueous fennel extract to manufacture probiotic yogurt resulted in a product with increased phenolic content and antioxidant activity compared to fresh yogurt.	[147]
Flaxseed	0–4%	Flaxseed was successfully added to yogurt containing *L. acidophilus* ATCC 4356. This yogurt had increased *L. acidophilus* counts, viscosity, hardness, cohesiveness, gumminess, and water holding capacity but decreased syneresis and adhesiveness compared to their control yogurt.	[148]
Sesame seeds	6%	Incorporation of roasted sesame into stirred yogurt improveds probiotic viability, sensory properties, and antioxidant properties.	[149]
Psyllium husk (Native and acid-modified psyllium husk)	0.5 g per liter of buffalo milk	Incorporation of psyllium husk into frozen yogurt containing the encapsulated probiotics *L. acidophilus* and *L. plantarum* formed a product with high consumer acceptability.	[150]
Oat β-glucan	0.15%	β-glucan and EPS-producing *B. bifidum* increased viscosity and water holding capacity but decreased syneresis.	[151]
Wheat bran	4%	Incorporation of wheat bran significantly increased total bacterial counts and titratable acidity.	[152]
Resisant starch (RS2 and RS3) [1]	1.5%	This yogurt was made from reconstituted skim milk. RS2 increased serum held within gel network. RS3 protected *B. animalis* subsp. *lactis* BB-12, increased viscosity, and decreased titratable acidity.	[153]
Chickpea flour	0, 1, 2.5, and 5%	Fortification of chickpea flour into probiotic yogurt resulted in improved water holding capacity and decreased syneresis for the resulting yogurt.	[154]
Fiber Ingredient			
Inulin of varying chain lengths [2]	1.5%	P95 lowered the pH but maintained similar flavor scores compared to the control. HP decreased syneresis and improved body and texture compared to the control.	[155]
Orange fiber	0.5, 1, 1.5, and 2%	Incorporating orange fiber into yogurt containing *L. acidophilus* LA-5 and *Bifidobacterium animalis* subsp. *lactis* BB-12 improved antioxidant activity and angiotensin converting enzyme (ACE)–inhibitory activity.	[156]
Lemon and orange fibers	3 g to 200 mL	The enriched fermented milk had good sensory acceptability. *L. acidophilus* and *L. casei* had better survival than *B. bifidum*.	[157]
Wolfberry dietary fiber (goji berry)	0.5–5%	Yogurt containing 2% (*w*/*v*) wolfberry dietary fiber had less syneresis, higher apparent viscosity, and increased hardness compared to control yogurt.	[158]
Fruit or fruit ingredient and vegetable			
Fruit purees (peach, apple, and pear)	10 and 20%	Peach and apples were the most suitable fruits for probiotic yogurt.	[159]
Dragon fruit	12%	The optimal formulation was 12% dragon fruit, 11% sugar, and 2% *L. plantarum*. Fermentation time was 19 h at 37 °C.	[160]
Isabel “Precoce” grape ingredients	Isabel grape preparation (20 g/100 mL) By-product flour (2 g/100 mL)	This goat milk yogurt had high *L. acidophilus* La-05 counts, distinct phenolic profile, higher antioxidant capacity, sensory acceptance, and consumer preference compared to control probiotic yogurt.	[161]
Orange sweet potato	15 and 25%	Orange sweet potato purees incorporated into probiotic yogurt were accepted by consumers.	[162]
Berry and nut			
Gobdin (Dry white mulberry and walnut paste)	0, 5, and 10%	Adding 5% gobdin to yogurt containing *L. acidophilus* resulted in an acceptable product.	[163]
Juice (fruit or vegetable)			

Functional Ingredient Category and Ingredient within category.	Concentration	Effect on Properties	Ref.
Pomegranate juice	16%	Yogurt fortified with pomegranate juice and probiotics had desirable sensory properties during storage.	[164]
Carrot juice	8, 16, 24, and 32%	There was increased color intensity, carrot flavor, creaminess, mouth coating, and chalkiness with increased carrot juice levels.	[165]
Juice and flower			
Juice from kiwifruit and jasmine flour	20% kiwi fruit juice and 15% jasmine flower juice	The best formulation was 20% kiwi fruit juice, 15% jasmine flower juice, and 5% inoculum concentration. Fermentation time was 8 h at 40 °C.	[166]
Spice and Oil			
Spices (Cardamom, cinnamon, and nutmeg)	0.5% (*v*/*w*)	Yogurts containing spices had good sensory properties with enhanced antioxidant activity.	[167]
Ginger and chamomile essential oil	0.2 and 0.4%	Ginger and chamomile essential oils and *B. lactis* Bb12 addition enhanced yogurt properties. Incorporation of essential oil significantly decreased fermentation time.	[168]
Dill essential oil	50 and 100 ppm	Yogurt containing 100 ppm dill essential oil received high sensory scores and maintained high viability of *B. bifidum* and *L. casei*.	[169]
Peppermint, Basil, and Zataria essential oils	0.5%	Antioxidant potential was improved by addition of all three essential oils. Peppermint and basil yogurts had acceptable sensory properties, but zataria yogurt was not as acceptable.	[170]
Bee products			
Pine honey	2, 4, and 6%	The 2% level was the preferred level during sensory evaluation.	[171]
Royal jelly	2% (*w*/*v*)	Royal jelly incorporation Ssignificantly improved physicochemical, rheological, sensory, and microbiological properties (increased probiotic viability) compared to control probiotic yogurt.	[172]
Cyanobacterium			
Spirulina (a biomass of cyanobacterium)	1 g per liter of yogurt mix.	This yogurt was less acidic than the control yogurt on the 7th day, and there was higher growth of lactic acid bacteria in this yogurt than for the control yogurt on the 7th day.	[173]

[1] RS2 is high amylose corn starch while RS3 is physically modified corn starch. [2] Inulin chain lengths were short (P95), medium (GR), and long (HP).

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