Probiotic potential of *Lactobacillus* strains isolated from different food sources

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Abstract: Probiotics are gaining popularity worldwide because people are getting aware of the health benefits provided by them. This review explains the major properties that a bacterial strain should possess to be used in the production of probiotic products. The review focuses mainly on the strains of *Lactobacillus* species with potential probiotic properties that have been isolated from the foods of different origins. These strains with potential probiotic properties can be evaluated further and can be used as starter cultures in the production of probiotic foods.

***Keywords*:** Probiotics, Lactobacillus, potential probiotic properties, starter cultures

INTRODUCTION

The term ‘probiotic’ is derived from a Greek word in which 'pro' means 'promoting' and 'biotic' means 'life'. The term probiotic generally refers to a few specific types of beneficial microbes contained in a probiotic supplement or added to food. Probiotics include friendly microbes that live normally in our digestive tract and are naturally present in fermented foods such as yogurt, pickles, etc. Probiotics compete successfully with the harmful microbes in our digestive tract by lowering their population they contribute towards gut health (Gary Huffnagle & Sarah Wernick, 2007). Lactobacillus species that are used as probiotics are *L. acidophilus, L. casei, L. gasser, L. johnsonii, L. paracasei, L. plantarum, L. reuteri, L. rhamnosus*, L. lactis. The strains that are used as probiotics should exhibit some special properties like acid and bile tolerance which is important for oral administration of probiotics, adhesion to mucosal and epithelial cells, bile salt hydrolase activity, antimicrobial activity against pathogenic bacteria (Kechagia et al. 2013). Lactobacillus belongs to the group of Lactic Acid Bacteria that can degrade carbohydrates. Some common characteristics of Lactic Acid Bacteria are gram-positive, cocci, coccobacilli, or rods that are non-spore-forming and most genera have a DNA base composition of less than 50% G+C, catalase-negative, prefers to grow under micro-aerophilic or anaerobic conditions, and typically ferment glucose mainly to lactic acid (homo-fermentative), but can also have lactic acid, CO2, and ethanol/acetic acid as end products (hetero-fermentative). It is found naturally in the gastrointestinal tract of mammals and fermented food products (George et al. 2018).

Probiotic evaluation of lactobacillus strains is essential to confer the required health benefits to the consumers the bacteria should arrive alive in the intestinal tract. It is also essential for the bacteria, that it must survive during food processing, product maturation, and storage. It is necessary that after consumption the bacteria should be resistant to the acidic conditions of the stomach and bile salts of the small intestine. The approach to protecting the microbe from processing and gastro-intestinal damage is micro-encapsulation (Liu et al. 2019). There is a huge demand for probiotics in the world as people are getting concerned about their health each day and they are aware of the health benefits that are related to probiotic consumption. "Guidelines for evaluations of probiotics in Food" were published by the Food and Agricultural Organization of the United Nations/ World Health Organization in 2002. These guidelines suggest the various criteria that can be used in probiotic selection (Araya et al. 2002).

Lactic acid bacteria may have a negative impact on the growth of *Helicobacter pylori* which is responsible for numerous gastrointestinal disorders from type B gastritis to gastric cancer. *H pylori* secrets urease enzyme to strive in the acidic environment of the stomach, LAB decreases the growth of *H pylori* in the stomach by decreasing the urease enzyme activity. *L. fermentum* SR 2 and *L. salivarius* SR16 are known to have a significant negative impact on the growth of *H. pylori* (Ryan et al. 2008). *Lactobacillus acidophilus* is known to have good antimicrobial activity against gastrointestinal pathogens and Lactobacillus bulgaricus is known to have the lowest antimicrobial activity against gastrointestinal pathogens (Philip et al. 2017). This antimicrobial activity of lactobacillus is linked to bacteriocin production as an antagonistic activity (Gibson et al. 2000). Twelve strains of lactobacillus that are known to have good antimicrobial activity are *Lactobacillus casei, Lactobacillus acidophilus Lactobacillus fermentum, Lactobacillus casei, Lactobacillus plantarum, Lactobacillus fermentum, Lactobacillus amylovorus, Lactobacillus plantarum, Lactobacillus casei, Lactobacillus pentosus, Lactobacillus acidophilus, Lactobacillus pentosusm* (Neha et al. 2017). The production of bacteriocins by lactobacillus strains can be used in biopreservation (Sarika et al. 2019). Bacteriocins produced by the strains of lactobacillus can be used as natural preservative agents in foods the activity of bacteriocins is heat stable and not affected by

alterations in ph from 1-4 (Tzu-Hsing et al. 2019). Commonly used bacteriocins in the dairy industry are nicin and pediocin AcH. Nicin and Pediocin PA-1/AcH are used in the meat industry for bio-preservation. Vegetable product industries make use of nisin in canned vegetables and fruits, pediocin PA-1/AcH in salad and fruit juices, and enterocin AS-48 is effective in preventing spoilage against *alicyclobacillus* (Singh, 2018).

To confer the desired benefits the probiotic strain must survive the acidic environment of the stomach. The acid tolerance of lactobacilli is due to a gradient between the pH of extracellular space and cytoplasm. Gram-positive organisms use the F-F1 ATPase mechanism to survive the acidic environment. The F-F1 ATPase creates a high intracellular pH at a low extracellular pH (Corcoran et al. 2005). Resistance to bile salts varies among *Lactobacillus* also among different strains. This property is due to the presence of BSH (bile salt hydrolase) an enzyme that reduces the toxic effect by conjugating bile. This activity is mostly found in those bacterial species which are isolated from the feces of animals. Among the various strains of lactobacilli *L. casei* ASCC 292 and *L. acidophilus* 4962 have good acid and bile tolerance as concluded by M.T. Liong and N.P. Shah (2005) from their experimental study on the acid and bile tolerance of the various strains of lactobacilli. *L. fermentum* SR2 and *L. gasseri* SR1 are also acid-tolerant (Ryan et al. 2008).

The properties of aggregation and adhesion are essential for probiotics as it leads to the formation of biofilms which protects the hosts from the invasions by pathogens. It was concluded from the study conducted by Grigoriyan et. al (2017) that *L. helveticus* INRA-2010-H11 and *L. acidophilus* JM-2012 show auto and co aggregation as well as adhesion to mice gut. Therefore, these strains have the potential to be used as probiotics. *L. acidophilus* M92 is known to have a good ability to establish itself in the human gastrointestinal tract due to its good auto-aggregation and adhesion ability (Kos et al. 2003).

Probiotic bacteria may have the potential to lower down cholesterol levels by the process of cholesterol assimilation. The study conducted by Duchesneau et. al (2014) demonstrates the ability of various strains of Lactobacillus to assimilate cholesterol among the various strains studied *L. plantarum* ATCC 14917 was found to be the best cholesterol assimilator grown in MRS Broth containing 100ug/ml of cholesterol–PEG 600 and *L. reuteri* NCIMB 701089 assimilated 67% of cholesterol under-stimulated intestinal conditions that are by using intestinal fluid containing Cholesterol-PEG 600 as the growth medium.

This review throws light on the *Lactobacillus* strains that are isolated from foods of different origins and screened for their probiotic potential so that they can be used as starter cultures in the manufacture of probiotic products. The strains that were found superior in their probiotic properties to other isolated strains and are of industrial importance to be used as starter cultures in probiotic product manufacture are stated in this review.

INDIAN FERMENTED FOODS

Fermentation is one of the traditional methods used worldwide to develop aroma, flavor, and texture in food products using microbes. It is also used to preserve and biologically enrich food products. Indian fermented foods include fermented vegetables like 'gundruk', 'sinki', fermented cereals, and pulses like ‘kinema’, ‘tungrimbai’, ‘dosa’ (Rawat et al. 2018). In the study conducted by Khagwal et al. (2019) samples of 102 traditional Indian fermented foods like Bhatura dough, idli batter, dosa batter, etc were collected aseptically and 200 microbial cultures were isolated using MRS media out of which 120 isolates tested catalase and oxidase negative. As they belonged to the Lactobacillus genus. Among 120 Lactobacillus isolates 7 isolates were found to be acid, bile, and pancreatic tolerant. These 7 isolates were further evaluated for other probiotic properties including anti-biotic resistance, hemolysis, auto-aggregation, and carbohydrate fermentation. The results obtained showed that the strains of *Lactobacillus plantarum* and *Lactobacillus fermentum* have excellent probiotic potential. These two strains were also found to be superior to *Lactobacillus casei* Shirota (LcS) the commercial probiotic strain that was used as control.

A traditional fermented beverage consumed by the tribal folks of Lahaul and Spiti of Himachal Pradesh is produced from the spontaneous fermentation of rice by the addition of traditional inoculum called ‘Phab’ is ‘chhang’. In the study conducted by Handa et al. (2016) lactic acid bacteria were isolated from chhang. These lactic acid bacteria were identified and evaluated for antagonistic activity against serious food-borne/spoilage-causing bacteria- *Staphylococcus aureus* IGMC, *Listeria Monocytogenes* MTCC 839, *Enterococcus faecalis* MTCC 2729, *Clostridium perfringens* MTCC 1739, *Leuconostoc mesenteroids* MTCC 107, and *Bacillus cereus* CRI. The highest metabolic activity was observed in *Lactobacillus plantarum* F22. Therefore, this strain was subjected to probiotic screening and was found to be acid and bile tolerant, anti-biotic sensitive, had strong autoaggregation and hydrophobicity, and was found suitable in the production of health foods.

Dosa is a south Indian fermented food produced by fermenting rice and black gram. In the study conducted by Gupta et al. (2014) lactic acid bacteria were isolated from various traditional Indian foods and *Lactobacillus plantarum* LD1 isolated from Dosa was selected for probiotic evaluation based on the anti-microbial property against *Micrococcus leuteus* MTCC106. It was concluded from this study that this strain can

be used in probiotic production as it was found acid and bile tolerant, possessed bile hydrolase activity, antibiotic sensitive except for Kanmicin as well as showed survival under stimulated conditions with antacids such as Eno.

Raabadi is a fermented beverage consumed in summers in the regions of Haryana and Rajasthan. The main ingredients of this are barley flour, pearl millet flour, buttermilk, salt, black pepper, cumin seed powder, and dry green coriander. In the study conducted on Raabadi samples, 24 lactobacillus isolates were subjected to in vitro probiotic evaluation, *L. plantarum* RYPR1 showed good probiotic potential out of the 24 strains. Therefore, this strain can be used in the production of probiotics (Yadav et al. 2016). The strain was found to be acid, bile, and lysozyme tolerant.

MEAT PRODUCTS

Using probiotic cultures for producing meat products is gaining popularity worldwide. Microbes isolated from traditional indigenous foods are widely used for this purpose. Isolating microbes with probiotic potential from meat products will be beneficial in the formation of probiotic meat products as these microbes are capable of adapting to the meat environment. The strains selected as starter cultures in probiotic meat product manufacture must possess the essential probiotic properties as well as the property of bacteriocin production to be able to survive among the well-adapted microbiota of the product (Ojha et al. 2015, Favaro et al. 2017).

In the study conducted by Moreno et al. (2018) five strains were isolated from meat products and tested for their probiotic properties. These five strains were L. lactis subsp. hordinae CTC 484, Lactobacillus plantarum CTC 368 and CTC 469, and Lactococcus lactis subsp. cremoris CTC 204 and CTC 483. All the isolated strains were found to be acid tolerant (pH 2), showed growth at a temperature of the gastrointestinal tract and the ability to form biofilms. The highest intensity of biofilm was produced by CTC 204. All the strains were amoxicillin sensitive and erythromycin-resistant. Also, CTC 204 was resistant to chloramphenicol, CTC 368, and CTC 469 to chloramphenicol and vancomycin, CTC 483 to tetracycline and vancomycin, and CTC 484 to clindamycin and chloramphenicol. CTC 469 was also found to be bile tolerant and it was concluded from the study that *L. lactis* subsp. cremoris CTC 204 and *Lactobacillus plantarum* CTC 368 strains had the greatest potential to be used as starter cultures in probiotic meat production.

Fermented sausages are considered to be a good carrier for probiotic bacteria because they are very mildly heated during processing but on the other hand, bacterial viability may be reduced due to high salt content, low water activity, and low pH. Therefore, the results of the studies to testing the probiotic potential of the strains isolated from fermented sausages will be strain dependent. Candidate probiotic strains have been isolated through probiotic screening of all the isolates obtained from fermented sausages that may be naturally present in the product. These isolates can then be used as starter cultures in the production of probiotic meat products (Vuyst et al. 2008).

PICKLED VEGETABLES

Paocai is a pickle made by a combination of acidified cabbage, carrot, cucumber, radish, and bamboo shoots and is a popular side dish in the homes of Taiwan. Paocai fermentation starts with the various microbes that are naturally present in the raw materials and at last lactic acid bacteria dominate. Taiwanese paocai is crunchy in texture and has a tangy taste. It is made by a combination of vegetables, spices, and other ingredients. The mode of fermentation in the production of paocai is anaerobic. In the study conducted by Chang et al. (2013) 33 strains were isolated from paocai and out of these 11 strains were found acid and bile-tolerant. These 11 strains were *Lactobacillus plantarum* (E1,E38,E46,E51,E55), *Lactobacillus casei* (E7,E15,E30,E33,E40) and *Lactobacillus rhamnosus* (E8). Adhesion to the monolayer of Caco 2 cells was highest in E51 and moderate in E33, E38. All isolated strains were found to inhibit food-borne pathogens *S. aureus, B. cereus, Shigella fexneri and S. typhimurium.*

Sauerkraut is prepared by fermenting shredded cabbage by lactic acid bacteria in the presence of 2-3% salt. In the study conducted by Yu et al. (2012) 7 strains of *Lactobacillus plantarum* were isolated from Chinese sauerkraut and these strains were subjected to probiotic evaluation. These 7 strains were S2-5, S2-6, S4-1, S52, S38, S56, and S72 among these 7 strains S2-5 and S4-1 can be used in the production of probiotic foods as they were found superior to other strains in probiotic evaluation. These strains were found to be acid and bile-tolerant, had high beta-galactosidase activity, showed adherence to Caco-2-cells, showed anti-microbial activity against *Escherichia coli* 0157, and *Shigella flexneri* CMCC(B), these strains were found resistant to kanamycin, vancomycin, polymyxin B, streptomycin and gentamycin. The highest cholesterol assimilation activity was observed in S4-1 in vitro study and was chosen for in vivo study. Other lactic acid bacteria that can be isolated from sauerkraut include *Lactobacillus brevis* and *Leuconostoc mesenteroids*. The probiotic potential of *Lactobacillus brevis* was studied by Singh et al. (2020) and *Lactobacillus brevis* ATCC 14869 was isolated from the sample of sauerkraut. This strain was found to be acid and bile tolerant, resistant to a broad range of antibiotics, and showed antagonistic activity against E. coli, K. pneumoniae, S. aureus, and P. aeruginosa.

L. brevis is a heterofermentative, gram-positive organism that can be isolated from foods such as sauerkraut, cheese, milk, mouth, and human intestinal tract**.**

A traditional fermented Korean vegetable mix made from Chinese cabbage, radish, red pepper powder, green onion, garlic, ginger, and fermented seafood. This dish is prepared at home and served as a side dish with meals. *Lactobacillus sakei* and *Lactobacillus plantarum* strains isolated from Kimchi were subjected to cholesterol assimilation tests. In the results, it was found that the majority of *L. sakei* strains reduced cholesterol from 50% to 60%, and two strains of *L. plantarum* isolated reduced cholesterol to about 48% (Lee et al. 2011).

- Table 1- % cholesterol assimilation from Lactobacillus isolated from kimchi (Lee et al. 2011).

Strains	%**cholesterol Assimilation**
L. sakei B6a4 I8 NR11 NR24 NR25 NR26 NR27 NR28 NR29 NR65 1stM3	40-60%
L. plantarum NR74	About 48%
L. Plantarum GC	About 48%

OLIVES

Olives are commonly consumed in the following processed forms- Spanish style which is alkali-treated green olives, the Californian style that ripe olives by alkaline oxidation, and natural olives that directly brined olives. *Lactobacillus pentosus* and *Lactobacillus plantarum* species, are the most important lactic acid bacteria present in table olives (Hurtado et al. 2012). In the work conducted by Cabello et al. (2020) 16 strains of *lactobacillus* were isolated from table olives and tested for immunomodulatory and anti-proliferative properties on epithelial human cellular lines. It was concluded from the results of the following tests that *Lactobacillus pentosus* LPG1, showed the best anti-inflammatory and immunomodulatory properties. Therefore, it has the potential to be used as a probiotic. The complex microbiota of table olives to identify probiotic organisms is not much investigated to date but this food matrix is a very good source of beneficial lactic acid bacteria (Botta et al. 2014). Probiotic lactic acid bacteria can be isolated from table olives and they can be incorporated in the formation of other fermented foods with enhanced nutritional and organoleptic properties. In the study conducted by Argyri et al. (2012) 71 lactic acid bacteria were isolated from table olives out of which 13 strains were of *Lactobacillus plantarum*, 37 were of *Lactobacillus pentosus*, 1 was of *Lactobacillus paraplantarum* and 2 were *Lactobacillus paracasei*. The reference strains used for the study were *Lactobacillus rhamnosus* GG and *Lactobaccillus casei* Shirota. The isolated strains were subjected to in vitro probiotic screening and the strains that were found superior to other isolated strains were *Lactobacillus pentosus* B281, *Lactobacillus pentosus* E97, *Lactobacillus pentosus* E104, *Lactobacillus pentosus* E108, *Lactobacillus plantarum* B282, *Lactobacillus plantarum* E10, *Lactobacillus plantarum* E69, *Lactobacillus paracasei* sub sp. paracasei E93 and *Lactobacillus paracasei* sub sp. paracasei E94. These strains were found acid and bile-tolerant. Two strains B282 and E10 showed partial hydrolysis to bile salts. All the strains were found to be Kanamycin resistant and maximum adherence to Caco 2 cells was shown by *Lactobacillus paracasei* sub sp. paracasei E94. These strains are good candidates to be used as starter cultures in the development of fermented probiotic products.

The traditional variety of table olives from the Apulian region in Southern Italy are Bella Di Cerignola. Special features of these olives are their big size and their green/black color of their skin. The method of production of these olives involves- Manual harvesting, transportation, grading, treatment with alkaline lye (1.3%- 2.6% NaOH) for 12-15 hours, washing, brining, and fermentation for 30-60 days in NaCl (Bevilacqua et. al 2010). Dominant lactic acid bacteria species found in Bella di Cerignola olives are *Lactobacillus plantarum*, *Lactobacillus brevis*, and *Leuconostoc mesenteroides* (Campaniello et al. 2005).

DAIRY PRODUCTS

Milk and its products are a very good source of lactobacilli. Lactobacillus species from milk have been isolated and identified in numerous studies. Lactobacilli that are naturally present or are intentionally added in milk and milk products provide flavor, nutritional value, and texture to these foods and provide additional health benefits to the consumers. Some species of lactobacilli that can be commonly isolated from milk samples of cows and buffalo are *L.fermentum, L.acidophilus, L.viridescens, L.brevis*, and *L.gasseri* (Mithun et al. 2015). *Lactobacillus alimentareus*, Lactobacillus sake, Lactobacillus colloids isolated from cheese, yogurt, buffalo milk, and cow milk showed anti-microbial activity against *S. aureus* (ATCC-6538), *B. subtilis* (ATCC-12711), and *P. aeruginosa* (ATCC-835). Therefore, these strains can be raised and incorporated in the preparation of functional foods (Karami et al. 2017).

Sheep milk is used to produce a traditional Iranian dairy product Koome it is produced in sheepskin bags in areas of rural Iran. Koome is the best traditional dairy product with a long shelf life. In the study conducted by Shemshad et al. (2021) fifteen isolates from Koome were subjected to probiotic evaluation. The results obtained from this study showed that *Lactobacillus crustorum* LMG 23699 and 20314 and *Lactobacillus brevis* ATCC 14869 were acid and bile-tolerant, anti-biotic resistant, cholesterol-reducing, bile salt hydrolyzing and *Lactobacillus crustorum* LMG 23699 showed anti-microbial activity against *Pseudomonas aeruginosa.* In the study conducted by Bao et. al (2010) Ninety strains of *Lactobacillus fermentum* were isolated from traditional dairy products and were screened for desirable probiotic traits such as acid and bile tolerance, aggregation activity, and antibacterial activity. In the in vitro probiotic screening 11 strains of Lactobacillus fermentum were found to contain the desirable probiotic properties. It was concluded from this study these 11 strains of *Lactobacillus fermentum*-IMAU60151, IMAU60092, IMAU60120, IMAU20084, IMAU60083, IMAU60071, F6, IMAU20044, IMAU20080, IMAU20081, IMAU60145 were found effective in vitro studies of probiotic evaluation and can be further evaluated in vivo for their probiotic potential. The results obtained from this study showed that *Lactobacillus fermentum* F6 showed the highest tolerance to acid and bile salts, broad anti-microbial activity, and good aggregation properties. Maragkaudakis et al. (2006) isolated twenty-nine *Lactobacillus* strains from dairy products and the isolates were screened for probiotic properties. Among these twenty-nine strains, three strains were the best based on pepsin, pancreatin and bile salts resistance, bile salt hydrolase activity, non-hemolytic behavior, anti-biotic resistant, adhesion to caco 2 cells, and inhibit the adhesion of *Escherichia coli* and *Salmonella typhimurium* to Caco-2 cells. These three strains that were found to possess the desired probiotic properties were *L. casei* Shirota ACA-DC 6002, *L. plantarum* ACA-DC 146, and *L. paracasei* subsp. *tolerans* ACA-DC 4037.

Tufail et al. (2011) isolated *Lactobacillus bulgaricus* strains from yogurt, isolated bacteriocin produced by *Lactobacillus bulgaricus*, and evaluated the anti-microbial activity of the bacteriocin against pathogenic and spoilage causing bacteria by agar well diffusion method. The results obtained from this study showed that *Lactobacillus bulgaricus* strains isolated from yogurts showed anti-bacterial activity against V. cholera and E. coli because a significant amount of bacteriocin was produced by these strains. The maximum bacteriocin was produced within an incubation period of 48 hours.

FLOWERS

A wide range of flowers is consumed by adding to foods and drinks to enhance their flavor and color to foods. In India, they are widely used in the preparation of sweet dishes. Fructose lactic acid bacteria are a group of lactic acid bacteria that use D-fructose over D glucose as a carbon source. These bacteria can be isolated from fruits and flowers because they are high in fructose content (Endo et al. 2009). The probiotic potential of fructose lactic acid bacteria has not been explored much. Fructose is a precipitation factor in irritable bowel syndrome and this syndrome can be prevented by fermenting cereals with fructose lactic acid bacteria. In the study conducted by Sakandar et al. (2019) three fructose lactic acid bacteria strains of *Lactobacillus kunkeei* (JNGBKS6, JNGBKS7, JNGBKS8) were isolated from Narcissus, yellow rose and pink rose from China. These strains when evaluated for their probiotic potential were found to be resistant to low pH, bile tolerant, cholesterol assimilatory, and antibiotic-resistance. These strains also showed anti-microbial activity against E. coli 25922, S. aureus NCTC 8325, and S. typhimurium CMCC5011.

TABLE OF CONCLUSIONS:

Table 2- Conclusions

Food	Isolated probiotic strain	Reference
1. Traditional Indian foods	*L. plantarum, L. fermentum*	Khagwal et al. (2019)
• Chhag • Dosa • Raabdi	*L. plantarum* F22 *L. plantarum* LD1 *L. plantarum* RYPR1	Handa et al. (2016) Gupta et al. (2014) Yadav et al. (2016)
2. Meat products	*L. lactis* subsp. *cremoris* CTC 204 *L. Plantarum* CTC 368	Moreno et al. 2018
3. Pickled vegetables		
• Paocai	*L. plantarum* (E1, E8, E46. E51, E55), *L. casei* (E7, E15, E30, E33,E40), *L. rhamnosus* (E8)	Chag et al. (2013)
• Sauerkraut	*L. plantarum* (S4-1) *L. brevis* ATCC14869	Yu et al. (2012) Singh et al. (2020)
• Kimchi	*L. plantarum* NR74, *L. Plantarum* GC	Lee et al. (2011)
4. Olives		
• Table olives	*L. pentosus* LPG 1 *L. paracasei* sub sp. paracasei E94, *L. plantarum* B282, *L. plantarum* E10	Cabello et al. (2020) Argyri et al. (2012)
5. Dairy products	*L. casei* Shirota ACA-DC 6002, *L. plantarum* ACA-DC 146 and *L. paracasei* subsp. *tolerans* ACA-DC 4037	Maragkaudakis et al. (2006)
• Koome	*Lactobacillus crustorum* LMG 23699, *Lactobacillus crustorum* 20314, *Lactobacillus brevis* ATCC 14869	Shemshad et. al (2021)
6. Flowers • Narcissus, yellow rose, and pink rose	*Lactobacillus kunkeei* (JNGBKS6, JNGBKS7, JNGBKS8)	Sakandar et. al (2019)

REFERNCES

- Akihito Endo, Yuka Futagawa-Endo, Leon M.T. Dicks, Isolation and characterization of fructophilic lactic acid bacteria from fructose-rich niches (2009). Systematic and Applied Microbiology, Volume 32, Issue 8, 593-600, https://doi.org/10.1016/j.syapm.2009.08.00
- Araya, M., Morelli, L., Reid, G., Sanders, M.E., Stanton, C., Pineiro, M., Ben Embarek, (2002) Guidelines for the evaluation of probiotics in food. Jt. FAO/WHO Work. Gr. Rep. Draft. Guidel. Eval. Probiotics Food. pp. 1–11. https://doi.org/10.1111/j.1469-0691.2012.03873.
- Argyri AA, Zoumpopoulou G, Karatzas KA, Tsakalidou E, Nychas GJ, Panagou EZ, Tassou CC. Selection of potential probiotic lactic acid bacteria from fermented olives by in vitro tests. Food Microbiol. 2013 Apr;33(2):282-91. doi: 10.1016/j.fm.2012.10.005. Epub 2012 Oct 31. PMID: 23200662.
- B. Kos, J. Suskovic, S. Vukovic, M. simpraga, J. Frece, S. Matosic . 2003. Adhesion and aggregation ability of probiotic strain Lactobacillus acidophilus M92. Journal of Applied Microbiology, vol94, issue 6
- B. M. Corcoran, C. Stanton, G.F. Fitzgerald, R. P. Ross (2005): Survival of probiotic lactobacilli in acidic environment is enhanced in the presence of metabolizable sugars. Applied and Environmental Microbiology.
- Benítez-Cabello A, Torres-Maravilla E, Bermúdez-Humarán L, Langella P, Martín R, Jiménez-Díaz R, Arroyo-López FN. Probiotic Properties of Lactobacillus Strains Isolated from Table Olive Biofilms. Probiotics Antimicrob Proteins. 2020 Sep;12(3):1071-1082. doi: 10.1007/s12602-019-09604-y. PMID: 31788768.

- Bevilacqua A, Altieri C, Corbo MR, Sinigaglia M, Ouoba LI. Characterization of lactic acid bacteria isolated from Italian Bella di Cerignola table olives: selection of potential multifunctional starter cultures. J Food Sci. 2010 Oct;75(8):M536-44. doi: 10.1111/j.1750-3841.2010.01793.x. Epub 2010 Sep 23. PMID: 21535510.
- Botta C, Langerholc T, Cencič A, Cocolin L. (2014) In vitro selection and characterization of new probiotic candidates from table olive microbiota. PLoS One. 2014 Apr 8;9(4):e94457. doi: 10.1371/journal.pone.0094457. PMID: 24714329; PMCID: PMC3979845.
- Campaniello D, Bevilacqua A, D'Amato D, Corbo MR, Altieri C, Sinigaglia M. 2005. Microbial characterization of table olives processed according to spanish and natural styles. Food Technol Biotechnol 43:289–94
- Catherine Tomaro-Duchedneau, Mitchell L Jones, Divya Shah, Ponam Jain, Shyamili Saha, Satya Prakash. 2014. Cholesterol assimilation by Lactobacillus probiotic bacteria; an in vitro investigation. BioMed research international.
- Favaro L, Todorov SD (2017) Bacteriocinogenic LAB strains for fermented meat preservation: perspectives, challenges, and limitations. Probiotics Antimicrob Proteins 9(4):444–458. https://doi.org/ 10.1007/s12602-017-9330-6
- Gary Huffnagle, Sarah Wernick(2007) The Probiotic Revolution .Vermilion London
- George R, Jayanta K, Patrab K, Goudac S, Parkb Y, Shind HS, Das G (2018) Benefaction of probiotics for human health: A review, Journal Of food and drug administration, Volume 26, Issue 3, July 2018, Pages 927-939
- Gibson, G.R. and Fuller R. (2000) Aspects of in Vitro and in Vivo Research Approaches Directed towards Identifying Probiotics and Probiotics for Human Use. Journal of Nutrition.
- Gupta A, Tiwari SK. Probiotic Potential of Lactobacillus plantarum LD1 Isolated from Batter of Dosa, a South Indian Fermented Food (2014) Probiotics Antimicrob Proteins. Jun;6(2):73-81. doi: 10.1007/s12602-014-9158-2.
- Heejae Lee, Hongsup Yoon, Yosep Ji, Hannah Kim, Hyunjoon Park, Jieun Lee, Heuynkil Shin, Wilhelm Holzapfel. (2011). Functional properties of Lactobacillus strains isolated from Kimchi. International Journal of Food Microbiology 145(1).
- Hurtado A, Requant C, Bordons A, Rozes N (2012) Lactic acid bacteria from fermented olives. Food Microbiol 31:1–8. https:// doi.org/10.1016/j.fm.2012.01.006
- Karami S, Roayaei M, Hamzavi H, Bahmani M, Hassanzad-Azar H, Leila M, Rafieian-Kopaei M (2017). Isolation and identification of probiotic *Lactobacillus* from local dairy and evaluating their antagonistic effect on pathogens. Int J Pharm Investig ;7(3):137-141. doi: 10.4103/jphi.JPHI_8_17
- Kechagia M, Basoulis D, Konstantopoulou S, Dimitriadi D, Gyftopoulou K, Skarmoutsou N, Fakiri EM, (2013) "Health Benefits of Probiotics: A Review", International Scholarly Research Notices.
- Liu H, Cui S W, Chen M, Li Y, Liang R, Xu F, Zhong F (2019) Protective approaches and mechanisms of microencapsulation to the survival of probiotic bacteria during processing, storage, and gastrointestinal digestion:a review; Critical Reviews on Food Science and Nutrition 59(17)
- Luc De Vuyst, Gwen Falony, FrédéricLeroy. 2008, Probiotics in fermented sausages. Meat Science, Volume 8, Issue 1 https://doi.org/10.1016/j.meatsci.2008.05.038
- M.T. Liong and N.P. Shah (2005): Acid and bile tolerance and cholesterol removal ability of lactobacillus. J. Dairy Sci, 88:55
- Maria Tufail, Shahzad Hussain, Farnaz Malik, Tahira Mirza, Ghazala Parveen, Shazia Shafaat, Amina Wajid, Rashid Mahmood, Rafique A. Channa and Alia Sadiq (2011). Isolation and evaluation of antibacterial activity of bacteriocin produced by Lactobacillus bulgaricus from yogurt. African Journal of Microbiology Research Vol. 5(22). DOI: 10.5897/AJMR11.846 I
- Moreno I, Marasca ETG, de Sá PBZR, de Souza Moitinho J, Marquezini MG, Alves MRC, Bromberg R. Evaluation of Probiotic Potential of Bacteriocinogenic Lactic Acid Bacteria Strains Isolated from Meat Products. Probiotics Antimicrob Proteins. 2018 Dec;10(4):762-774. doi: 10.1007/s12602-018-9388-9. PMID: 29396844.
- Neha Khagwal1 , D.C. Sharma2 and P.K. Sharma (2019) Isolation and Characterization of Potential Probiotic Strains Isolated from Traditional Indian Fermented Foods, International Journal of Current Microbiology and Applied Sciences, Volume 8.Number 03, https://doi.org/10.20546/ijcmas.2019.803.084
- Nina Shemshad, Leila Roozbeh Nasiraie, Reza Majidzadeh Herav (2021). Isolation of Probiotic Lactobacilli Bacteria from Traditional Naein Dairy Product (Koome) Iranian Journal of Medical Microbiology 15(1): 85-106
- Ojha KS, Kerry JP, Duffy G, Beresford T, Tiwari BK (2015) Technological advances for enhancing quality and safety of fermented meat products. Trends Food Sci Technol 44(1):105– 116. https://doi.org/10.1016/j.tifs.2015.03.010 10.
- Petros A. Maragkoudakis, Georgia Zoumpopoulou, Christos Miaris, George Kalantzopoulos, Bruno Pot, Effie Tsakalidou (2006). Probiotic potential of Lactobacillus strains isolated from dairy products, International Dairy Journal, Volume 16, Issue 3, 2006, 189-199, https://doi.org/10.1016/j.idairyj.2005.02.009.
- Rawat, K. Kumari, S. Kumar, R. and Gehlot R. (2018). Traditional Fermented products of India. Int. J. Curr. Microbial .App. Sci.7(4):1873-1883
- Ruby Yadav, Anil K. Puniya and Pratyoosh Shukla, 2016; Frontiers in Microbiology.
- Ryan KA, Daly P, Li Y, Hooton C, Toole PWO (2008) Strain-specific inhibition of Helicobacter pylori by Lactobacillus salivarius and other lactobacilli. Journal of Antimicrobial Chemotherapy 61(4)
- S. Grigoriyan, I. Bazukyan, A. Trchounian (2017): Aggregation and Adhesion Activity of Lactobacillus Isolated from Fermented Products In Vitro and In Vivo: a potential probiotic strain. Springer
- Sakandar, H. A., Kubow, S., & Sadiq, F. A. (2019). *Isolation and in-vitro probiotic characterization of fructophilic lactic acid bacteria from Chinese fruits and flowers. LWT.* https://doi.org/10.1016/j.lwt.2019.01.038.
- Sarangdhar Mithun, Vora Dipak and Sarang Sheela (2015), Isolation and Identification of lactobacilli from raw milk samples obtained from Aarey Milk Colony, International Journal for Scientific and Research Publication, Volume-5, Issue 4
- Sarika AR, Lipton AP, and Aishwarya MS (2019) Bio-preservation efficiency of Bacteriocin GP 1 of Lactobacillus rhamnosus GP 1 on stored fish fillets. Frontiers in Nutrition Food Mirobiology.
- Shiao-Ming Chang, Chi-Lin Tsai , Wan-Chen Wee and Tsong-Rong Yan. (2013) Isolation and functional study of potentially probiotic Lactobacilli from Taiwan traditional paocai. African Journal of Microbiology Research Vol. 7(8), pp. 683-691
- Shweta Handa, Nivedita Sharma (2016). In vitro study of probiotic properties of *Lactobacillus plantarum* F22 isolated from chhang-A traditional fermented beverage of HP India. Journal of Genetic Engineering and Biotechnology 14(91-97)

- Tanaka, H., Doesburg, K., Iwasaki, T. and Mireau I. (1999): Screening of lactic acid bacteria for bile salt hydrolase activity. Journal of Dairy Science, 82, 2530-2535.
- Tzu-Hsing Lin, Tzu-Ming Pan(2019): Characterization of an antimicrobial substance produced by *Lactobacillus plantarus* NTU 102. Journal of Microbiology, Immunology and Infection (Vol 52, issue 3)
- Veer Pal Singh(2018) Recent approaches in food bio-preservation. Open veterinary journal 8(1)
- Yan Bao, Yanchao Zhang, Yong Zhang, Yong Liu, Shuiquan Wang, Ximei Dong, Yanyan Wang, Heping Zhang(2010) Screening of potential probiotic properties of Lactobacillus fermentum isolated from traditional dairy products. Food Control, Volume 21, Issue 5,695-701, https://doi.org/10.1016/j.foodcont.2009.10.010.
- Yu, Z., Zhang, X., Li, S. et al (2013) Evaluation of probiotic properties of Lactobacillus plantarum strains isolated from Chinese sauerkraut. World J Microbiology Biotechnology 29**,** 489–498 (2013). https://doi.org/10.1007/s11274-012-1202-3
- Vaishali Singh, Suman Ganger and Shweta Patil (2020) Characterization of Lactobacillus brevis with Potential Probiotic Properties and Biofilm Inhibition against Pseudomonas aeruginosa Proceedings, 66, 14; doi:10.3390/proceedings2020066014