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A Review on Probiotic and Health Benefits of Probiotics

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A B S T R A C T

Probiotics are kind of live and beneficial microorganisms that reside in the gastrointestinal tract of human and rodent and also naturally found in the fermented milk products. The probiotic correlation between consumption of probiotic and amelioration of metabolic problems has been confirmed by various studies. The microbes most commonly used as probiotic are lactic acid bacteria. Moreover, numerous strains of probiotic are belonging to genus *Lactobacillus bifidobacterium*. Moreover effects of probiotic has been reported to be strain dependent, although plethora of studies are coming throughout The world on health benefits of probiotics, still there is confusion about specific and accurate way by which probiotic influence the metabolism in general disorder. Therefore probiotics bacteria improve health by different mechanism such as improve hypercholesterolemia by binding of cholesterol to cell surface, assimilation of cholesterol, co-precipitation of cholesterol and finally lower the blood cholesterol. Probiotics have impact on obesity by lowering body weight, regulating lipid and glucose metabolism, have improvement of diabetes by improving insulin resistance, blood glucose level and also probiotics have role on improvement of colon cancer. This review more focuses on advantage effective of probiotics on health.

Introduction

About 10^{14} bacteria live in the colon of humans. Imbalance in gut microbiota may result in numerous metabolic disorder viz. obesity, diabetes, heart ailment, Dysbiosisin in gut microbiota, results in to oxidation of more energy from undigested food (Turnbaugh *et al.*, 2009). Initiation of fat storage (Suppressing Fiaf) altering the gut peptides synthesis `related to homeostasis of energy for example glucagon like peptide YY and peptide-1 and metabolic endotoximia (higher LPS imbalance). Metabolic endotoximia, low grade inflammation, insulin resistant and other metabolic disorders. Therefore function and structure of the intestinal microbiota should be normalized, the ultimate method for normalizing the gut microbiota is by oral intake of probiotic (Kopp *et al.*, 2009).

Bifidobacterium and *Lactobacillus* are the genera of bacteria mostly used as probiotics. *Lactobacillus* are lactic acid bacteria which are used for food preservation and fermentation for thousands years. Lactic acid

bacteria are Gram positive, non-toxic, non-pathogenic fermentative bacteria, which produces the lactic acid from carbohydrates during fermentation of food. *Saccharomyces boulardii* which is a yeast also used as probiotic. But some other species of bacteria such as *Bacillus* and *E. coli* are also being used as probiotic (Hütt *et al.*, 2006).

History of probiotic

Probiotics are kind of microorganisms, generally reside in the gastrointestinal tract of host. These are symbiotic microorganism, according to studies and investigation they have beneficial effect on host. The probiotic word derivative from the Latin (*pro)* and Greek (*bio*) literally meaning "for life". History of probiotics is as old as human history, as it is firmly related to the utilization of fermented food. Metchnikoff known as father of probiotics at the starting of 20th century, he was the first conceptualize of probiotics. Metchnikoff in 1907 suggested that there are some kinds of bacteria present in the fermented milk products that produce acids, if consumed habitually, lead to healthier and long life. The probiotic (*Lactobacillus bulgaricus*) discovered by Metchnikoff was involved in the combination of fermented milk.

In 1953 probiotics introduced by the German scientist Werner Kollath "are kind of active substances that are essential for health development." In 1954 Vergin introduced term of probiotics for the first time, while he was working on the antibiotic and other microbial compound detrimental impact on the gut microbiota. He found "probiotika" which is favorable for the gut microbiota. In 1965, Stillwell and Lilly defined probiotics as "substances secreted by one organism which stimulate the growth of another organism." More specifically, Fuller in (1992) defined probiotic as "a live microbial food supplement which usefullyimpacts the host by improving intestinal microbial balance.'' (Gasbarrini *et al.,* 2016) And there were also other researcher which had their own different definition for probiotic. In 2001 World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nation developed well-defined probiotic, as probiotics are "live microorganism, which, when administrated in adequate amounts, confer health benefit on the host." These kind of microbe can be bacteria, yeast or viral and generally can be seen under microscope (Gasbarrini *et al.,* 2016) (Table 1).

Mechanism of action of probiotics

Have competition for nutrients.

Antimicrobial compounds such as organic acid, dipicolinicacid, bacteriosin and hydrogen peroxide are yielded by which the development of disease causing microbes is hampered.

Have competition for adhesion sites (colonization resistance) and Alters the pathogenic bacteria through development of biofilm.

Reducing the yield of molecules related to inflammation (IL-6, TNF-α).

It normalizes the intestinal gut microbiota.

Calcium and other minerals absorption is enhanced.

Intestinal gut permeability is improved

By reducing luminal pH, it acts as a barrier to the development of disease causing enteric bacteria.

Its metabolic product reduces the toxigenic and mutagenic reaction.

Production of Butyric acid, Butyric acid is consumed by enterocytes.

Enhance the fat oxidation.

Enhance the level of adiponecetin. (Faujdar *et al.,* 2016)

Health benefits of probiotics

In the recent years researchers are more interest to work on role of probiotics on

human health. Okuro *et al.*, (2013) defined probiotic as feed supplement of live microbial which have beneficial effect on host such as to improve balance of gut microbiota, eliminate or decreasing aliment like irritation of colon (Holowacz *et al.*, 2016), lowering of blood ammonia levels, inhibition of pathogenic microorganism, inhibition of tumor formation, cholesterol absorption (Ebel *et al.*, 2014), synthesis of vitamin, enhanced absorption of calcium (Gu and Li *et al.*, 2016). Probiotic interact with potential of pathogenic microbes or commensal and produce metabolic compound and other product like short chain fatty acids and conducting with cells of host via chemical signaling, colonized and lead to inhibit pathogenic microorganisms (Collado *et al.*, 2007).

Proposed health benefits stemming from probiotics consumption

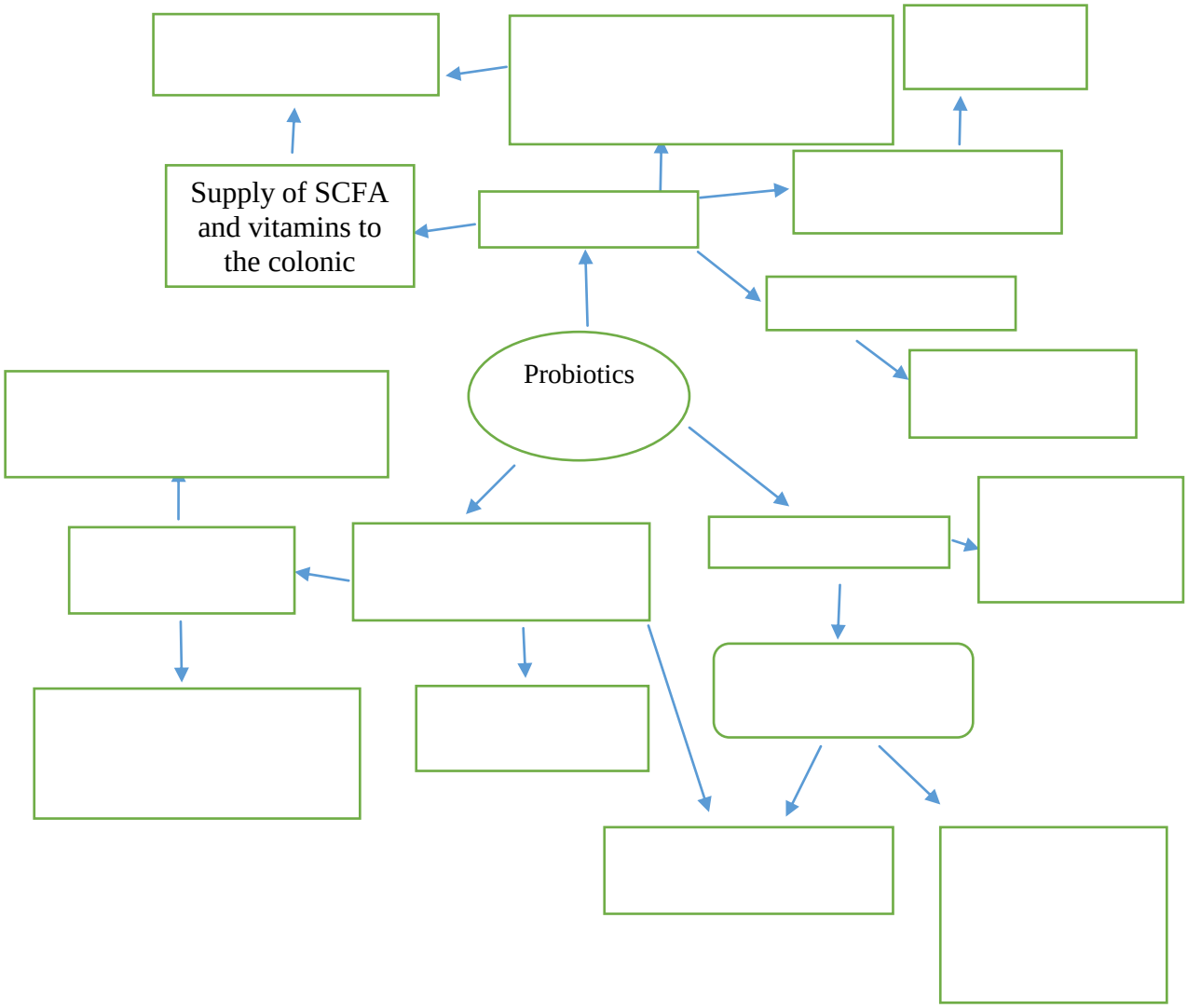

Table.1 Different strains of probiotics bacteria which have different beneficial effects

No.	Probiotics Used	Model	Beneficial effects	References
1	*L. plantarum*	Human	Reduced γ-glutamyltrancspeptidease, T-cholesterol, glucose and LDL	(Barreto *et al.*, 2014)
2	*B. lactis* HN019	Human	Reduced T cholesterol, body weight, LDL, interleukin-6proinflamatory factor and tumor necrosis factor	(Bernini *et al.*, 2016)
3	*L. acidophilus* NCFM	Human	Insulin sensitivity improve in type2 diabetes	(Andreasen *et al.*, 2010)
4	*L. gasseri* BNR17	*db/db* mice	Improved diabetes, suppressing blood glucose level	(Yun *et al.*, 2009)
5	*L. reuteri* GMN 32	Rats	Prevent DC in DM rats and regulate blood glucose level	(Lin *et al.*, 2014)
6	*L. casei* Supplementation	Human	Type 2 diabetes	(Khalili *et al.*, 2019)
7	*L. rhamnosus* GG	Rats	Hypercholesterolemia	(Sangwan *et al.*, 2018)
8	*L. fermentum* FTDC 8312	Mice	Hypercholesterolemia, decrease T-cholesterol and LDL-C, increase HDL-C	(Lye *et al.*, 2017)
9	*L. rhamnosus* GG	Mice *C57BL/6J*	Non-alcoholic fatty liver disease and dyslipidemia	(Kim *et al.*, 2016)
10	*L. plantarum* LRCC 5273	Mice *C57BL/6*	Hypercholesterolemia and cardiovascular disease	(Heo *et al.*, 2018)
11	*L. plantarum* CUL 66	In vitro	BSH, lowering cholesterol and cholesterol metabolism (cholesterol homeostasis	(Michael *et al.*, 2016)
12	*L. gasseri* SBT 2055	*Sprague Dawley* Rats	Glucose tolerance and anti-obesity effect	(Shirouchi *et al.*, 2016)
13	*L. rhamnosus* NCDC 17	Rats	Type 2 diabetes	(Singh *et al.*, 2017)
14	*L. plantarum* SCS2	Mice	Hypoglycemic effect	(Meng *et al.*, 2016)
15	*L. plantarum*MTCC 5690 and *L. fermentum* MTCC 5689	*C57BL/6J* Mice	Insulin resistance and type 2 diabetes	(Balakumar *et al.*, 2018)
16	*L. casei* CCFM 419	*C57BL/6J* Mice	Hyperglycemic in type 2 diabetes and insulin resistance	(Li *et al.*, 2017)

Probiotics and hypercholesterolemia

As per WHO cardiovascular diseases (CVD) will affect around 23.6 million individuals around the world by 2030 and will be the lead cause of death (WHO). In CVD cholesterol accumulates abnormally (hypercholesterolemia) in the veins as well as arteries, and this accumulation leads to obstruction in the flow of blood (atherosclerosis). Higher level of LDL-C is correlated with the higher risk of hypercholesterolemia. Probability of heart attack is observed to be three times more in hypercholesterolemic person than those who have normal blood lipid profile (Ebel *et al.,* 2014). Exact cause of hypercholesterolemia is not known till now. But eating habits along with sedentary lifestyle could be considered as one of the putative cause in occurrence of hypercholesterolemia.

Many drugs such as statin (simvastatins, atorvasstains, pitavastains) are available in the market for lowering the cholesterol levels in the blood. Statins inhibits the activity of the enzyme involved in cholesterol biosynthesis in the liver (Bellosta *et al.,* 2004) but some researchers have reported the side effects (muscular pain and muscle weakness) of statin (Kim *et al.,* 2017). Now-days many reports are available indicating the beneficial effects of probiotics on hypercholesterolemia both in humans and rodents without side effects (Cavallini *et al.,* 2009; Yin *et al.,* 2010). Different mechanisms for lowering cholesterol by probiotics have been reported by different workers. Probiotics *L. rhamnosus*BFE5264 lowers the cholesterol levels in blood by incorporating the cholesterol in their plasma membrane and increased cholesterol excretion through faeces(Mathara *et al.,* 2008).

L. casei LC2WL probiotics bacteria degrades the bile salts by their BSH activity (Xiong *et al.,* 2017), Probiotic *L. plantarum* NCU116 increases the LDL-C receptor (or by development of expression of LDL-c gene) in the liver (Li *et al.,* 2014). *L. plantarum* CA16 alone or in combination with *L. rhamnosus* GG exhibited the hypocholesterolemic effects in mice fed high fat diet supplemented with cholesterol (Kumar *et al.,* 2013; Wang *et al.,* 2013)*L. rhamnosus* GG exhibited the beneficial effects in hyperlipidemic rats through modulation of gastrointestinal gut microbiota(Kumar *et al.,* 2013). Yogurts containing *B. longum* BB536 have been reported to decrease levels of TG, LDL-C and TC in hypercholesterolemic albino rats (Al-Sheraji *et al.,* 2012). *B. longum* SPM1207 fermented yoghurt improved the dyslipidemia in humans (Kurpad*et al.,* 2018). Mixture of few probiotics was observed to be more effective in improving the hypercholesterolemia than single strain of probiotic (Chang *et al.,* 2017). Mixture of five probiotics were reported to be more effective in the treatment of nonalcoholic fatty liver disease (NAFLD), improvement of dyslipidemia, inflammatory markers and liver function (Al-muzafar *et al.,* 2017).Similarly mixture of two *Lactobacillus* strains (*L. plantarum*and *L. reuteri*) and mixture of three *bifidobacterial* strains (*B. breve, B. longum* and *B. lactis*) have significant effect in decreasing serum TG, LDL-cholesterol and TC in hypercholesterolemic rats (Chang *et al.,* 2017).

Probiotics and obesity

Obesity and its associated metabolic disorders viz. diabetes, hypertension, cardiovascular disease, non-alcoholic fatty liver disease and insulin resistance are increasing epidemically throughout the world. In 2008 approximately one-third of adult population in the world (1.46 billion people) was overweight as well as obese, and obesity had been reported to more in females than males (Frühbeck *et al.,*

2013). Many factors viz. environmental, host genome, diets, modern societies were reported to be the cause of the obesity. In addition dysbiosis of gut microbiota is also considered as additional factor in occurrence of type II diabetes mellitus and obesity (Moreno-Indias *et al.,* 2014).

Probiotics have been reported to exert anti-obesity effects (Alard *et al.,* 2016), and different probiotics have been reported to have different mechanism in lowering body weight (Park and Bae *et al.,* 2015). *L. plantarum* 9-41-A and *L. fermentum* M1-16 probiotics have been reported to have beneficial effects by regulating lipid and glucose metabolism (Xie *et al.,* 2011), *L. GG* lowers endotoxaemia (Bajaj *et al.,* 2014), some probiotic for instance *L. plantarum* produces the conjugated linoleic acid (Dahiya and Puniya *et al.,* 2017), some probiotics like *L. gasseri* SBT2055 reduces the cell size (hypertrophy) and increases the cell number (hyperplasia) in white adipose tissue (Hamad *et al.,* 2008) and some like *L. casei* NCDC19 even increases the energy expenditure by increases the expression of genes related to the metabolism of lipid (Jangra *et al.,* 2019; Miyoshi *et al.,* 2014).

Whereas supplementation of *L. plantarum* LG42 decrease, the expression of lipogenic genes (ACC, LXR-α, and SREBP-1) in liver tissue, expression of PPAR-α and CTP-1, responsible for beta-oxidation of fatty acid, increases in mice. Also *L. plantarum* decreases the expression of C/EBP-α and PPAR-γ genes (Park *et al.,* 2014). Lowering of PPAR gamma could be correlated with reduced differentiation of adipocytes and reduced storage of fats under such conditions. *Lactobacillus paracasei* F19 exhibited the antiobesity effects in mice by increasing the levels of ANGPTL4, an inhibitor of lipoprotein lipase (LPL). Low LPL activity has been correlated with reduced fat storage in adipocytes (Tanida *et al.,* 2008). Some probiotics improves the insulin resistance in mice through increasing the natural killer cells (Ma, *et al.,* 2008). Some probiotics increases the bifodobacterial numeral in the colon (Rather *et al.,* 2014). Some probiotics produces short chin fatty acids such as butyrate, propionate and acetate and these fatty acids have been reported to regulate food intake and induces the satiety through gut peptides (GLP-1, PYY) (Torres-Fuentes *et al.,* 2015). VSL#3 has been reported to increase the GLP-1 production through butyrate produced by colonic fermentation. GLP-1 decreased the food intake, reduced adiposity and improve glucose tolerance in mice (Liang *et al.,* 2014). But health benefits of probiotics had been conveyed to be strains dependent. Some researchers had conducted probiotic don't have effect on body weight (Jangra *et al.,* 2019) and even some have reported gain in body weight due to consumption of probiotics (Stenman *et al.,* 2016).

Probiotics and diabetes

Recent studies have shown that more than 382 million individuals are suffering from diabetes around the globe. Diabetes mellitus is of two kinds, diabetes mellitus type and diabetes mellitus type 2. Pancreas do not synthesizes the insulin in T1DM. But in T2DM body do not respond to the insulin produced by pancreas (insulin resistance). Probiotics have been reported to be effective in improving the insulin resistance, and different mechanisms have been proposed by different researchers. Beneficial effects on blood glucose levels are considered as one of the reasons in improving insulin resistance. Glucose levels in the blood is considered directly proportional to blood insulin levels (Hsieh *et al.,* 2013). Reduced body weights were considered another possible mechanism in improving insulin resistance and diabetes.

There are many reports suggesting the positive correlation in between insulin resistance and body weight (Alemzadeh *et al.,* 2008).

Many reports showed that the oral take of probiotic have positive effects on oxidative stress, metabolic lipid profile and high sensitivity C-reactive protein in T2DM patients. Mixture of probiotics (*L. casei, L. acidophilus, L. bulgaricus, L. rhamnosus, Streptococcus thermophiles, B. longum, B. breve*) ingested for eight weeks exhibited the hypoglycaemic effects (Asemi *et al.,* 2013). Improvements in insulin resistance could be expected under hypoglycaemic conditions as glucose triggers the release of insulin from the beta cells of the pancreas. Recently, feeding of *L. casei*NCDC19 fermented milk along with sucrose and high fat diet to the c57bl/6 mice for 18 weeks have been reported to lower the glucose of blood, insulin serum and HOMA-IR score significantly when compared to group fed high-fat and sucrose diet only (Jangra *et al.,* 2019).

Probiotics and Dyslipidemia

High fat diet has been reported to cause dyslipidemia. Many probiotics have been reported to improve the high fat diet associated dyslipidemia. Although many mechanisms have been suggested by different workers but exact mechanism of action is yet to be elucidated. Hypoglycemia is considered as important factor that leads to improvement of dyslipidemia because both glucose and insulin are considered as driver for lipogenesis (Basciano *et al.,* 2005). Probiotics hypoglycemic effects had been have been described by different workers (Al-Salami *et al.,* 2008). Decreased expression lipogenicgenes (Srebf1/Srebp1c, Srebf1/Srebp1c, Mlxipl, Nr1h5, Fasn, Acacb, Scd1Gck) and increased expression of lipolytic genes (cpt1, ppar alpha) by probiotics has also been reported by different workers (Jangra *et al.,* 2019), and that leads to improvement of dyslipidemia.

Improved insulin resistance, decreased tumor necrosis factor α and total cholesterol in the serum of patients suffering from NAFLD has been reported and possible mechanism reported was decreased aspartate transaminase, aminotransferase activity. Combination of Streptococcus, *Lactobacillus* and *Bifidobacterium* was given these patients (Jain *et al.,* 2004), *VSL#3* has also been reported to improve dyslipidemia (Alisi *et al.,* 2014; Jain *et al.,* 2004). *L. casei* NCDC19 has also been conveyed to improve dyslipidemia in mice fed high fat diet (Jangra *et al.,* 2019; Rather *et al.,* 2014). *Lactobacillus rhamnosus* GG (LGG) has shown protective effects against NAFLD in mice. In these mice beneficial bacteria number increased, gut barrier function improved and subsequently liver inflammation was decreased (Ritze *et al.,* 2014).

Probiotics and hyperglycemia

High concentration of glucose leads to several metabolic disorders viz. obesity, cardiovascular disease and diabetes millitu. Feeding of probiotics (*L. casei* and *L. acidophilus*) with high fructose diets improved diabetes, lipid and glucose metabolism, hyperglycemia, oxidative stress, dyslipidemia, hyperinsulinemia, and inhibited glucose intolerance in rats (Shewale *et al.,* 2014; Yadav *et al.,* 2008). Ingestion of *L. gasseri* BNR17 in *db/db* mice decreased the body weight and improved the glucose metabolism in type 2 diabetes (Yun *et al.,* 2009).

Mechanism of action of probiotics in lowering blood glucose is still not clear. Yadav and his colleagues (Yadav *et al.,* 2007). Reported feeding of yogurt containing

*L. casei*and *L. acidophilus* to animals inhibited the glucose intolerance, hyperinsulinemia, and hyperglycemia and oxidative stress was found to be reduced in these animals. Probiotics improved the low grade inflammation as well as immune responses (decreasing the cytokines numbers) (de LeBlanc *et al.,* 2010), by inhibiting the NF-K pathway (Shi *et al.,* 2006), Some of the specific strains of LAB improved the hyperglycemia through their antioxidant properties (Amaretti *et al.,* 2013). Feeding the *Lactobacillus johnsonii*(La1) for two weeks reduced the hyperglycemic and lowered the insulin resistance (Laitinen*et al.,* 2008). This probiotic reported to modulate the gut microbiota which obstructed the uptake of glucose, and more blood glucose absorption by liver (Mohammad-Shahi *et al.,* 2017). Hence, modulation of the gut microbiota by supplementing the probiotics could be another way of lowering blood glucose.

Probiotics effects on colon cancer

Probiotics have been reported to have beneficial effects on colon cancer (Liong *et al.,* 2008). There are many ways through which probiotic confers anti-carcinogenic effects (Gillessen *et al.,* 2018). These are as follows:

- Formation of compounds with anti-carcinogenic properties (short chain fatty acids and conjugated linoleic) (Uccello *et al.,* 2012).
- Inhibits the binding of mutation causing microorganisms in the colon.
- Decrease in the activity of enzymes involve in production of carcinogens. Probiotic suppresses the colon enzymes viz. β-glucosidase, β-glucuronidase, nitrate reductase, zoredutase and 7-α-dehydroxlase. These enzymes involved in the conversion of inactive carcinogens into active carcinogens such as ammonia, cresols, phenols, and N-nitroso compounds (Kumar *et al.,* 2013).
- Decrease the nephrotoxic, mycotoxins, and genotoxic immunosuppressive substances.
- Physical binding between the cancer causing compounds and peptidoglycan some probiotic microorganisms could exhibit anti-carcinogenic activity (Gillessen *et al.,* 2018).

The efficacy of probiotic strains viz. *Lactobacillus fermentum* NCIMB5221 and *Lactobacillus fermentum*NCIMB8829 in hampering colorectal cancer cells, and increase the growth of normal epithelial colon cells with SCFAs (ferulic acid) have been shown by in vitro experiments (Tomaro-Duchesneau *et al.,* 2012). Some studies *in vitro* have reported the beneficial effects of probiotics on colon cancer. Though, further studies are necessary to delineate the pathway by which probiotics confers anti-cancerous effects. Moreover, more clinical and animal trials are needed in this regard.

Probiotics and gut microbiota

Trillions of bacteria are residing in the human gut (Koboziev *et al.,* 2014). Gut microbiota has been reported to confer many functions to the host such as vitamin production, bioactive compounds production, immune modulation, degradation of carcinogens and toxins, maintenance of intestinal epithelia and inhibition of colonization of pathogens in the colon (Zhang *et al.,* 2015). Recent reports have correlated the dysbiosis of gut microbiota (low number of bifidobacteria and lactobacilli) with the occurrence of obesity (Daillère *et al.,* 2016). Many mechanisms for association of dysbiosis with lifestyle disorders have been proposed by different workers which are described below as:

Capability to extract more energy from the undigestible food (Turnbaugh *et al.*, 2006).

Suppressing intestinal Fiaf expression (LPL inhibitor) which leads to more fat storage in the adipocytes (Cani and Delzenne *et al.*, 2009).

Affecting gut peptides synthesis, involved in energy homeostasis such as glucagon like peptide 1and peptide YY.

Increase in lipopolysaccharides level in circulation (metabolic endotoxaemia) which is supposed to cause insulin resistance and chronic low-grade inflammation.

The best way for controlling the flora balance in intestine is through intake of probiotics. There are many reports that show a direct relationship between the intake of probiotics and the improvement of metabolic disorders (Heczko *et al.,* 2006). Probiotics are defined by the WHO and FAO (WHO/FAO, 2002) as live microorganisms that confer health benefits upon the host when administered in adequate amounts. Intake of appropriate dose of a probiotic plays an important role in conferring the beneficial effects. Commonly used probiotics belong to *Lactobacillus, Bifidobacterium* and *Saccharomyces* genera. To confer health benefits, probiotics must colonize (even temporally) in the colon after oral intake (Goldin and Gorbach *et al.,* 2008).

Positive correlation between metabolic endotoxaemia and bifidobacterial counts in the colon of mice has been reported (Cani *et al.,* 2007). Bifidobacterial counts in the colon decreased with the intake of high fat diet, and that lead to metabolic endotoxaemia and other metabolic disorders in the mice. Oral intake of bifidobacteria with high fat diet restored the bifidobacterial counts in the colon, and negative effects of high fat diet were reversed (Moya-Pérez *et al.,* 2015). Higher number of bifidobacteria in the colon of mice fed high fat diet along with *L. casei*NCDC19 fermented dahi has also been reported (Rather *et al.,* 2014).

Other ways to increase health beneficial bacteria (Probiotic) in the colon

Prebiotics

Prebiotics (generally oligosaccharides) are defined as indigestible part of the food that reaches the colon as such and selectively stimulates the activity of beneficial microorganisms (probiotics) in the colon of the host (Gibson *et al.,* 2004). Cereals (wheat, barley, oats etc.), vegetables (onion, garlic, tomato, leafy green vegetables etc.) and fruits (banana, apple etc.) are considered as potential source of prebiotic. Galactooligosaccharides (GOS), lactulose and maltooligosaccharides are artificial prebiotics, and most effective on stimulating the growth of probiotic (Patterson *et al.,* 2003).Many literatures have reported the increment in the amount of beneficial microorganisms in the colon upon consumption of prebiotics both in rodents and humans (Legette *et al.,* 2012; Messaoudi *et al.,* 2011). Selectively stimulating the growth of the beneficial microorganism in the colon is considered one of the mechanisms through which prebiotics confers their health benefits to the host (Pandey *et al.,* 2015). A prebiotic must possess some features in order to stimulate the growth of probiotics in the colon such as

a) must not be absorb in intestinal
b) indigestible or partially digestible
c) should not be fermented in oral cavity by bacteria
d) must be fermented selectively in colon to stimulate the growth of microorganisms

In the colon short chain fatty acids (mainly butyrate, propionate and acetate) are produced

when prebiotics is fermented in the colon (Fernández *et al.,* 2016). Butyrate is considered source of energy for the enterocytes of intestinal cells. Propionate is reported to protect against diet induced obesity (Barczynska *et al.,* 2015).

Synbiotics

Synbiotic is considered another approach by which number of beneficial microorganisms can be increased in the gut. In this approach probiotics and prebiotics are used together in order to get synergistic effects (Kearney *et al.,* 2018). In synbiotic formulation substrate (prebiotic) for probiotics is readily available for the fermentation. This helps in improvement of survivability issues of probiotics as they pass through the harsh conditions of the gastrointestinal tract. A very few studies are available where health benefits of synbiotics were evaluated in high fat diet fed conditions.

In conclusion, the present review more focused on different beneficial effect of probiotics. Information obtained from the *in vivo* and *in vitro* studies exhibited probiotics are suitable option for treatment and prevention of diseases without side effects. Hypocholesterolemic effects of probiotics are one of the greatest health impacts of probiotics. That improve hypercholesterolemia through the binding of cholesterol to cell surface, cholesterol assimilation, co-precipitation of cholesterol, deconjugation of bile acids by BSH activity, and multi strains of probiotics more effective in the treatment of non-alcoholic fatty liver disease.Probiotics have been reported to exert anti-obesity and different probiotics have been reported to have different mechanism in lowering body weight through the regulating lipid and glucose metabolism, producing of the conjugated linoleic, reducing the cell size (hypertrophy) and increases the cell number (hyperplasia) in white adipose tissue, increasing the energy expenditure by increases the expression of genes related to lipid metabolism. Probiotics have been reported to be effective in improving the insulin resistance. Beneficial effects on blood glucose levels are considered as one of the reasons in improving insulin resistance. Probiotic have positive effects on oxidative stress, metabolic lipid profile and high sensitivity C-reactive protein in T2DM patients. Many probiotics improve the high fat diet associated dyslipidemia through the decreasing of expression lipogenic genes (Srebf1/Srebp1c,Scd1Gck) and increased expression of lipolytic genes (cpt1, ppar alpha) and that leads to improvement of dyslipidemia. Probiotics have beneficial effects on colon cancer, Through Formation of compounds with anti-carcinogenic.Inhibits the binding of mutation causing microorganisms in the colon. Decrease in the activity of enzymes involve in production of carcinogens. Still, more studies and scientific improvements are necessary to found the probiotics health benefits and potential application.

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References

Al-muzafar, Hessah Mohammed and Kamal Adel Amin. 2017. "Probiotic Mixture Improves Fatty Liver Disease by Virtue of Its Action on Lipid Profiles, Leptin, and Inflammatory Biomarkers." *BMC Complementary and Alternative Medicine* 17(1):43.

Al-Salami, Hani, Grant Butt, J. Paul Fawcett, Ian G. Tucker, Svetlana Golocorbin-Kon, and Momir Mikov. 2008. "Probiotic treatment reduces blood glucose levels and increases systemic absorption of gliclazide in diabetic rats." *European Journal of Drug Metabolism and Pharmacokinetics*

33(2):101–6.

Al-Sheraji, Sadeq Hasan, Amin Ismail, Mohd Yazid Manap, Shuhaimi Mustafa, Rokiah Mohd Yusof, and Fouad Abdulrahman Hassan. 2012. "Hypocholesterolaemic effect of yoghurt containing *Bifidobacterium pseudocatenulatum* G4 or *Bifidobacterium longum* BB536." *Food Chemistry* 135(2):356–61.

Alard, Jeanne, Véronique Lehrter, Moez Rhimi, Irène Mangin, Véronique Peucelle, Anne- Laure Abraham, Mahendra Mariadassou, Emmanuelle Maguin, Anne- Judith Waligora- Dupriet, and Bruno Pot. 2016. "Beneficial metabolic effects of selected probiotics on diet- induced obesity and insulin resistance in mice are associated with improvement of dysbiotic gut microbiota." *Environmental Microbiology* 18(5):1484–97.

Alemzadeh, Ramin, Jessica Kichler, Ghufran Babar, and Mariaelena Calhoun. 2008. "Hypovitaminosis D in obese children and adolescents: relationship with adiposity, insulin sensitivity, ethnicity, and season." *Metabolism* 57(2):183–91.

Alisi, A., G. Bedogni, G. Baviera, V. Giorgio, E. Porro, C. Paris, P. Giammaria, L. Reali, F. Anania, and V. Nobili. 2014. "Randomised clinical trial: the beneficial effects of VSL# 3 in obese children with non- alcoholic steatohepatitis." *Alimentary Pharmacology & Therapeutics* 39(11):1276–85.

Amaretti, Alberto, Mattia Di Nunzio, Anna Pompei, Stefano Raimondi, Maddalena Rossi, and Alessandra Bordoni. 2013. "Antioxidant properties of potentially probiotic bacteria: *in vitro* and *in vivo* activities." *Applied Microbiology and Biotechnology* 97(2):809–17.

Andreasen, Anne Sofie, Nadja Larsen, Theis Pedersen-Skovsgaard, Ronan M. G. Berg, Kirsten Møller, Kira Dynnes Svendsen, Mogens Jakobsen, and Bente Klarlund Pedersen. 2010. "Effects of *Lactobacillus acidophilus* NCFM on insulin sensitivity and the systemic inflammatory response in human subjects." *British Journal of Nutrition* 104(12):1831–38.

Asemi, Zatollah, Zohreh Zare, Hossein Shakeri, Sima-sadat Sabihi, and Ahmad Esmaillzadeh. 2013. "Effect of multispecies probiotic supplements on metabolic profiles, hs-crp, and oxidative stress in patients with type 2 diabetes." *Annals of Nutrition and Metabolism* 63(1–2):1–9.

Bajaj, Jasmohan S., Douglas M. Heuman, Phillip B. Hylemon, Arun J. Sanyal, Puneet Puri, Richard K. Sterling, Velimir Luketic, R. Todd Stravitz, Muhammad S. Siddiqui, and Michael Fuchs. 2014. "Randomised clinical trial: *Lactobacillus* GG Modulates gut microbiome, metabolome and endotoxemia in patients with cirrhosis." *Alimentary Pharmacology & Therapeutics* 39(10):1113–25.

Balakumar, Mahalingam, Durai Prabhu, Chandrakumar Sathishkumar, Paramasivam Prabu, Namita Rokana, Ramesh Kumar, Srividhya Raghavan, Avinash Soundarajan, Sunita Grover, and Virender Kumar Batish. 2018. "Improvement in glucose tolerance and insulin sensitivity by probiotic strains of Indian gut origin in high-fat diet-fed C57BL/6J Mice." *European Journal of Nutrition* 57(1):279–95.

Barczynska, R., K. Bandurska, K. Slizewska, M. Litwin, M. Szalecki, Z. Libudzisz, and J. Kapusniak. 2015. "Intestinal microbiota, obesity and prebiotics." *Pol J Microbiol* 64(2):93100.

Barreto, Fabíola Málaga, Andréa Name Colado Simão, Helena Kaminami

Morimoto, Marcell Alysson Batisti Lozovoy, Isaias Dichi, and Lúcia Helena da Silva Miglioranza. 2014. "Beneficial Effects of *Lactobacillus plantarum* on glycemia and homocysteine levels in postmenopausal women with metabolic syndrome." *Nutrition* 30(7–8):939–42.

Basciano, Heather, Lisa Federico, and Khosrow Adeli. 2005. "Fructose, insulin resistance, and metabolic dyslipidemia." *Nutrition & Metabolism* 2(1):5.

Bellosta, Stefano, Rodolfo Paoletti, and Alberto Corsini. 2004. "Safety of statins: focus on clinical pharmacokinetics and drug interactions." *Circulation* 109(23_suppl_1): III-50.

Bernini, Luciana Jesus, Andrea Name Colado Simão, Daniela Frizon Alfieri, Marcell Alysson Batisti Lozovoy, Naiara Lourenço Mari, Cínthia Hoch Batista de Souza, Isaias Dichi, and Giselle Nobre Costa. 2016. "Beneficial effects of *Bifidobacterium lactis* on lipid profile and cytokines in patients with metabolic syndrome: A randomized trial. Effects of Probiotics on Metabolic Syndrome." *Nutrition* 32(6):716–19.

Cani, Patrice D. and Nathalie M. Delzenne. 2009. "The role of the gut microbiota in energy metabolism and metabolic disease." *Current Pharmaceutical Design* 15(13):1546–58.

Cani, Patrice D., Audrey M. Neyrinck, F. Fava, Claude Knauf, Rémy G. Burcelin, Kieran M. Tuohy, G. R. Gibson, and Nathalie M. Delzenne. 2007. "Selective increases of *Bifidobacteria* in gut microflora improve high-fat-diet-induced diabetes in mice through a mechanism associated with endotoxaemia." *Diabetologia* 50(11):2374–83.

Cavallini, Daniela C. U., Raquel Bedani, Laura Q. Bomdespacho, Regina C. Vendramini, and Elizeu A. Rossi. 2009. "Effects of probiotic bacteria, isoflavones and simvastatin on lipid profile and atherosclerosis in cholesterol-fed rabbits: a randomized double-blind study." *Lipids in Health and Disease* 8(1):1.

Chang, Hung-Yang, Jin-Hua Chen, Jui-Hsing Chang, Hung-Chih Lin, Chien-Yu Lin, and Chun-Chih Peng. 2017. "Multiple strains probiotics appear to be the most effective probiotics in the prevention of necrotizing enterocolitis and mortality: An Updated Meta-Analysis." *PLoS One* 12(2):e0171579.

Collado, M. C., J. Meriluoto, and S. Salminen. 2007. "Role of Commercial probiotic strains against human pathogen adhesion to intestinal mucus." *Letters in Applied Microbiology* 45(4):454–60.

Dahiya, Dinesh Kumar and Anil Kumar Puniya. 2017. "Isolation, molecular characterization and screening of indigenous lactobacilli for their abilities to produce bioactive Conjugated Linoleic Acid (CLA)." *Journal of Food Science and Technology* 54(3):792–801.

Daillère, Romain, Marie Vétizou, Nadine Waldschmitt, Takahiro Yamazaki, Christophe Isnard, Vichnou Poirier-Colame, Connie P. M. Duong, Caroline Flament, Patricia Lepage, and Maria Paula Roberti. 2016. "*Enterococcus hirae* and *Barnesiella intestinihominis* facilitate cyclophosphamide-induced therapeutic immunomodulatory effects." *Immunity* 45(4):931–43.

Ebel, Bruno, Guillaume Lemetais, Laurent Beney, Rémy Cachon, Philippe Langella, Patrick Gervais, Bruno Ebel, Guillaume Lemetais, Laurent Beney, Rémy Cachon, Bruno Ebel, Guillaume Lemetais, Laurent Beney, Harry Sokol, and Philippe Langella. 2014. "Impact of

probiotics on risk factors for cardiovascular diseases. a review impact of probiotics on risk factors for cardiovascular diseases. A Review." 8398(December 2016).

Faujdar, Sameer Singh, Priya Mehrishi, Surabhi Bishnoi, and Amisha Sharma. 2016. "Role of probiotics in human health and disease: an update." *International Journal of Current Microbiology and Applied Sciences* 5(3):328–44.

Fernández, Javier, Saul Redondo-Blanco, Ignacio Gutierrez-del-Rio, Elisa M. Miguélez, Claudio J. Villar, and Felipe Lombo. 2016. "Colon microbiota fermentation of dietary prebiotics towards short-chain fatty acids and their roles as anti-inflammatory and antitumour agents: A Review." *Journal of Functional Foods* 25:511–22.

Frühbeck, Gema, Hermann Toplak, Euan Woodward, Volkan Yumuk, Max Maislos, and Jean-Michel Oppert. 2013. "Obesity: The gateway to ill health-an easo position statement on a rising public health, clinical and scientific challenge in Europe." *Obesity Facts* 6(2):117–20.

Gasbarrini, Giovanni and Fiorenza Bonvicini. 2016. "Probiotics History." 50(December):116–19.

Gibson, Glenn R., Hollie M. Probert, Jan Van Loo, Robert A. Rastall, and Marcel B. Roberfroid. 2004. "Dietary modulation of the human colonic microbiota: updating the concept of prebiotics." *Nutrition Research Reviews* 17(2):259–75.

Gillessen, Silke, Gerhardt Attard, Tomasz M. Beer, Himisha Beltran, Alberto Bossi, Rob Bristow, Brett Carver, Daniel Castellano, Byung Ha Chung, and Noel Clarke. 2018. "Management of patients with advanced prostate cancer: the report of the advanced prostate cancer consensus conference APCCC 2017." *European Urology* 73(2):178–211.

Goldin, B. R. and S. L. Gorbach. 2008. "Clinical indications for probiotics: an overview." *Clinical Infectious Diseases* 46(Supplement_2):S96–100.

Gu, Qing and Ping Li. 2016. "Biosynthesis of vitamins by probiotic bacteria." in *Probiotics and Prebiotics in Human Nutrition and Health*. IntechOpen.

Hamad, Essam M., Masao Sato, Kazunori Uzu, Takeshi Yoshida, Seiichiro Higashi, Hiroshi Kawakami, Yukio Kadooka, Hiroaki Matsuyama, Ibrahim A. Abd El-Gawad, and Katsumi Imaizumi. 2008. "Milk fermented by *Lactobacillus gasseri* SBT2055 influences adipocyte size via inhibition of dietary fat absorption in Zucker rats." *British Journal of Nutrition* 101(5):716–24.

Heczko, P., M. Strus, and P. Kochan. 2006. "Critical Evaluation of probiotic activity." *Journal of Physiology and Pharmacology* 57(9):5–12.

Heo, Wan, Eui Seop Lee, Hyung Taek Cho, Jun Ho Kim, Jin Hyup Lee, Seok Min Yoon, Hoon Tae Kwon, Siyoung Yang, and Young-Jun Kim. 2018. *"Lactobacillus plantarum* LRCC 5273 isolated from Kimchi Ameliorates diet-induced hypercholesterolemia in C57BL/6 mice." *Bioscience, Biotechnology, and Biochemistry* 82(11):1964–72.

Holowacz, S., C. Blondeau, I. Guinobert, A. Guilbot, S. Hidalgo-Lucas, and J. F. Bisson. 2016. "Antidiarrheal and Antinociceptive Effects of a Probiotic Mixture in Rats." *J. Prob. Health* 4(3).

Hsieh, Feng-Ching, Chia-Lin Lee, Chee-Yin Chai, Wan-Tzu Chen, Ying-Chen Lu, and Ching-Shuang Wu. 2013. "Oral Administration of *Lactobacillus reuteri* GMNL-263 improves insulin resistance and ameliorates hepatic steatosis in high

fructose-fed rats." *Nutrition & Metabolism* 10(1):35.

Hütt, P., J. Shchepetova, K. Loivukene, T. Kullisaar, and M. Mikelsaar. 2006. "Antagonistic activity of probiotic *Lactobacilli* and *Bifidobacteria* against entero- and uropathogens." *Journal of Applied Microbiology* 100(6):1324–32.

Jain, Prashant K., Clare E. McNaught, Alexander D. G. Anderson, John MacFie, and Charles J. Mitchell. 2004. "Influence of Synbiotic containing *Lactobacillus acidophilus* La5, *Bifidobacterium lactis* Bb 12, *Streptococcus thermophilus*, *Lactobacillus bulgaricus* and oligofructose on gut barrier function and sepsis in critically ill patients: a randomised controlled trial." *Clinical Nutrition* 23(4):467–75.

Jangra, S., R. K. Sharma, R. Pothuraju, and G. Bhakri. 2019. "Milk Fermented with *Lactobacillus casei* NCDC19 improves high fat and sucrose diet alters gene expression in obese mice." *International Dairy Journal* 90:15–22.

Kearney, Sean M. and Sean M. Gibbons. 2018. "Designing synbiotics for improved human health." *Microbial Biotechnology* 11(1):141.

Khalili, Leila, Beitullah Alipour, Mohammad Asghari Jafar-Abadi, Ismail Faraji, Tohid Hassanalilou, Mehran Mesgari Abbasi, Elnaz Vaghef-Mehrabany, and Mahmood Alizadeh Sani. 2019. "The effects of *Lactobacillus casei* on glycemic response, serum sirtuin1 and fetuin-a levels in patients with type 2 diabetes mellitus: A Randomized Controlled Trial." *Iranian Biomedical Journal* 23(1):68.

Kim, Bobae, Kun-Young Park, Yosep Ji, Soyoung Park, Wilhelm Holzapfel, and Chang-Kee Hyun. 2016. "Protective effects of *Lactobacillus rhamnosus* GG against dyslipidemia in high-fat diet-induced obese mice." *Biochemical and Biophysical Research Communications* 473(2):530–36.

Kim, Shang-Jin, Sang Park, Hong-Sig Sin, Seung-Hwan Jang, Sang-Wang Lee, Seon-Young Kim, Bora Kwon, Kang-Yeol Yu, Su Kim, and Dong Yang. 2017. "Hypocholesterolemic effects of probiotic mixture on diet-induced hypercholesterolemic rats." *Nutrients* 9(3):293.

Koboziev, Iurii, Cynthia Reinoso Webb, Kathryn L. Furr, and Matthew B. Grisham. 2014. "Role of the enteric microbiota in intestinal homeostasis and inflammation." *Free Radical Biology and Medicine* 68:122–33.

Kopp, Matthias V and Peter Salfeld. 2009. "Probiotics and Prevention of allergic disease." *Current Opinion in Clinical Nutrition & Metabolic Care* 12(3):298–303.

Kumar, Amit. 2013. "Probiotics: Nature's Medicine." *International Journal of Nutrition, Pharmacology, Neurological Diseases* 3(3):219.

Kumar, Manoj, Shruti Rakesh, Ravinder Nagpal, R. Hemalatha, A. Ramakrishna, V. Sudarshan, Ramesh Ramagoni, Mohd Shujauddin, Vinod Verma, and Ashok Kumar. 2013. "Probiotic *Lactobacillus rhamnosus* GG and aloe vera gel improve lipid profiles in hypercholesterolemic Rats." *Nutrition* 29(3):574–79.

Kurpad, Anura V. 2018. "Potential of Probiotics in Hypercholesterolemia: A Review of In Vitro and In Vivo Findings." *Alternative Therapies in Health and Medicine* 24(2):36–43.

Laitinen, Kirsi, Tuija Poussa, and Erika Isolauri. 2008. "Probiotics and dietary counselling contribute to glucose regulation during and after pregnancy: a randomised controlled trial." *British Journal of Nutrition* 101(11):1679–87.

de LeBlanc, Alejandra de Moreno and Gabriela Perdigón. 2010. "The application of probiotic fermented milks in cancer and intestinal inflammation." *Proceedings of the Nutrition Society* 69(3):421–28.

Legette, LeeCole L., WangHee Lee, Berdine R. Martin, Jon A. Story, Jessica K. Campbell, and Connie M. Weaver. 2012. "Prebiotics Enhance magnesium absorption and inulin- based fibers exert chronic effects on calcium utilization in a postmenopausal rodent model." *Journal of Food Science* 77(4):88–94.

Li, Chuan, Shao-Ping Nie, Qiao Ding, Ke-Xue Zhu, Zhi-Jun Wang, Tao Xiong, Joshua Gong, and Ming-Yong Xie. 2014. "Cholesterol-lowering effect of *Lactobacillus plantarum* NCU116 in a hyperlipidaemic rat model." *Journal of Functional Foods* 8:340–47.

Li, X., E. Wang, B. Yin, D. Fang, P. Chen, G. Wang, J. Zhao, H. Zhang, and W. Chen. 2017. "Effects of *Lactobacillus casei* CCFM419 on Insulin resistance and gut microbiota in type 2 diabetic mice." *Beneficial Microbes* 8(3):421–32.

Liang, Shuwen, Tonya Webb, and Zhiping Li. 2014. "Probiotic Antigens Stimulate Hepatic Natural Killer T Cells." *Immunology* 141(2):203–10.

Lin, Chih-Hsueh, Cheng-Chieh Lin, Marthandam Asokan Shibu, Chiu-Shong Liu, Chia-Hua Kuo, Fuu-Jen Tsai, Chang-Hai Tsai, Cheng-Hong Hsieh, Yi-Hsing Chen, and Chih-Yang Huang. 2014. "Oral *Lactobacillus reuteri* GMN-32 Treatment reduces blood glucose concentrations and promotes cardiac function in rats with streptozotocin-induced diabetes mellitus." *British Journal of Nutrition* 111(4):598–605.

Liong, Min-Tze. 2008. "Roles of probiotics and prebiotics in colon cancer prevention: postulated mechanisms and in-vivo evidence." *International Journal of Molecular Sciences* 9(5):854–63.

Lye, Huey-Shi, Tamotsu Kato, Wai-Yee Low, Todd D. Taylor, Tulika Prakash, Lee-Ching Lew, Hiroshi Ohno, and Min-Tze Liong. 2017. "*Lactobacillus fermentum* FTDC 8312 combats hypercholesterolemia via alteration of gut microbiota." *Journal of Biotechnology* 262:75–83.

Ma, Xiong, Jing Hua, and Zhiping Li. 2008. "Probiotics improve high fat diet-induced hepatic steatosis and insulin resistance by increasing hepatic nkt cells." *Journal of Hepatology* 49(5):821–30.

Mathara, Julius Maina, Ulrich Schillinger, Claudia Guigas, Charles Franz, Phillip Museve Kutima, Samuel K. Mbugua, H. K. Shin, and Wilhelm H. Holzapfel. 2008. "Functional characteristics of *Lactobacillus* Spp. from traditional maasai fermented milk products in Kenya." *International Journal of Food Microbiology* 126(1–2):57–64.

Meng, Xiao, Yu Qian, Li-Shi Jiang, Jin-Mei Kang, Yan Chen, Juan Wang, Shu-Kun Liu, Zhen-Ming Che, and Xin Zhao. 2016. "Effects of *Lactobacillus plantarum* SCS2 on blood glucose level in hyperglycemia mice model." *Applied Biological Chemistry* 59(1):143–50.

Messaoudi, Michaël, Nicolas Violle, Jean-François Bisson, Didier Desor, Hervé Javelot, and Catherine Rougeot. 2011. "Beneficial psychological effects of a probiotic formulation (*Lactobacillus helveticus* R0052 and *Bifidobacterium longum* R0175) in healthy human volunteers." *Gut Microbes* 2(4):256–61.

Michael, D. R., J. W. E. Moss, D. Lama Calvente, I. Garaiova, S. F. Plummer, and D. P. Ramji. 2016. "*Lactobacillus plantarum* CUL66 can impact

cholesterol homeostasis in Caco-2 enterocytes." *Beneficial Microbes* 7(3):443–51.

Miyoshi, Masaya, Akihiro Ogawa, Satoshi Higurashi, and Yukio Kadooka. 2014. "Anti-obesity effect of *Lactobacillus gasseri* SBT2055 accompanied by inhibition of pro-inflammatory gene expression in the visceral adipose tissue in diet-induced obese mice." *European Journal of Nutrition* 53(2):599–606.

Mohammad-Shahi, Majid, Masoud Veissi, Fatemeh Haidari, Hajieh Shahbazian, Gholam-Abas Kaydani, and Fatemeh Mohammadi. 2017. "Effects of probiotic yogurt consumption on inflammatory biomarkers in patients with type 2 diabetes." *BioImpacts* 4(2):83–88.

Moreno-Indias, Isabel, Fernando Cardona, Francisco J. Tinahones, and María Isabel Queipo-Ortuño. 2014. "Impact of the gut microbiota on the development of obesity and type 2 diabetes mellitus." *Frontiers in Microbiology* 5:190.

Moya-Pérez, Angela, Alexander Neef, and Yolanda Sanz. 2015. "*Bifidobacterium pseudocatenulatum* CECT 7765 reduces obesity-associated inflammation by restoring the lymphocyte-macrophage balance and gut microbiota structure in high-fat diet-fed mice." *PLoS One* 10(7):e0126976.

Okuro, Paula K., Marcelo Thomazini, Júlio C. C. Balieiro, Roberta D. C. O. Liberal, and Carmen S. Fávaro-Trindade. 2013. "Co-encapsulation of *Lactobacillus acidophilus* with inulin or polydextrose in solid lipid microparticles provides protection and improves stability." *Food Research International* 53(1):96–103.

Pandey, Kavita R., Suresh R. Naik, and Babu V Vakil. 2015. "Probiotics, prebiotics and synbiotics-a review." *Journal of Food Science and Technology* 52(12):7577–87.

Park, J- E, S- H Oh, and Y- S Cha. 2014. "Lactobacillus Plantarum LG 42 Isolated from Gajami Sik- hae Decreases body and fat pad weights in diet- induced obese mice." *Journal of Applied Microbiology* 116(1):145–56.

Park, Sunmin and Ji-Hyun Bae. 2015. "Probiotics for weight loss: a systematic review and meta-analysis." *Nutrition Research* 35(7):566–75.

Patterson, J. A. and K. M. Burkholder. 2003. "Application of prebiotics and probiotics in poultry production." *Poultry Science* 82(4):627–31.

Rather, Sarver A., Ramesh Pothuraju, Raj Kumar Sharma, Sachinandan De, Nazir A. Mir, and Surender Jangra. 2014. "Anti- obesity effect of feeding probiotic dahi containing lactobacillus casei ncdc 19 in high fat diet- induced obese mice." *International Journal of Dairy Technology* 67(4):504–9.

Ritze, Yvonne, Gyöngyi Bárdos, Anke Claus, Veronika Ehrmann, Ina Bergheim, Andreas Schwiertz, and Stephan C. Bischoff. 2014. "*Lactobacillus rhamnosus* GG protects against non-alcoholic fatty liver disease in mice." *PloS One* 9(1):e80169.

Sangwan, Seema and Rameshwar Singh. 2018. "Synergistic effect of oats and lgg fermented milk on lowering hypercholesterolemia in rats." *Journal of Cereal Science* 82:164–69.

Shewale, Ravi N., Pravin D. Sawale, C. D. Khedkar, and Ajay Singh. 2014. "Selection criteria for probiotics: a review." *International Journal of Probiotics & Prebiotics* 9.

Shi, Hang, Maia V Kokoeva, Karen Inouye, Iphigenia Tzameli, Huali Yin, and Jeffrey S. Flier. 2006. "TLR4 links innate immunity and fatty acid–induced insulin resistance." *The Journal of Clinical Investigation* 116(11):3015–25.

Shirouchi, Bungo, Koji Nagao, Minami Umegatani, Aya Shiraishi, Yukiko Morita, Shunichi Kai, Teruyoshi Yanagita, Akihiro Ogawa, Yukio Kadooka, and Masao Sato. 2016. "Probiotic *Lactobacillus gasseri* SBT2055 improves glucose tolerance and reduces body weight gain in rats by stimulating energy expenditure." *British Journal of Nutrition* 116(3):451–58.

Singh, S., R. K. Sharma, S. Malhotra, R. Pothuraju, and U. K. Shandilya. 2017. "*Lactobacillus rhamnosus* NCDC17 Ameliorates type-2 diabetes by improving gut function, oxidative stress and inflammation in high-fat-diet fed and Streptozotocin treated rats." *Beneficial Microbes* 8(2):243–55.

Stenman, L. K., R. Burcelin, and S. Lahtinen. 2016. "Establishing a causal link between gut microbes, body weight gain and glucose metabolism in humans–towards treatment with probiotics." *Beneficial Microbes* 7(1):11–22.

Tanida, Mamoru, Jiao Shen, Keiko Maeda, Yuko Horii, Toshihiko Yamano, Yoichi Fukushima, and Katsuya Nagai. 2008. "High-fat diet-induced obesity is attenuated by probiotic strain *Lactobacillus paracasei* ST11 (NCC2461) in rats." *Obesity Research & Clinical Practice* 2(3):159–69.

Tomaro-Duchesneau, Catherine, Shyamali Saha, Meenakshi Malhotra, Michael Coussa-Charley, Imen Kahouli, Mitchell L. Jones, Alain Labbé, and Satya Prakash. 2012. "Probiotic ferulic acid esterase active *Lactobacillus fermentum* NCIMB 5221 APA microcapsules for oral delivery: preparation and in vitro characterization." *Pharmaceuticals* 5(2):236–48.

Torres-Fuentes, Cristina, Harriët Schellekens, Timothy G. Dinan, and John F. Cryan. 2015. "A natural solution for obesity: bioactives for the prevention and treatment of weight gain. A Review." *Nutritional Neuroscience* 18(2):49–65.

Turnbaugh, Peter J., Micah Hamady, Tanya Yatsunenko, Brandi L. Cantarel, Alexis Duncan, Ruth E. Ley, Mitchell L. Sogin, William J. Jones, Bruce A. Roe, and Jason P. Affourtit. 2009. "A core gut microbiome in obese and lean twins." *Nature* 457(7228):480.

Turnbaugh, Peter J., Ruth E. Ley, Michael A. Mahowald, Vincent Magrini, Elaine R. Mardis, and Jeffrey I. Gordon. 2006. "An obesity-associated gut microbiome with increased capacity for energy harvest." *Nature* 444(7122):1027.

Uccello, Mario, Giulia Malaguarnera, Francesco Basile, Velia D'agata, Michele Malaguarnera, Gaetano Bertino, Marco Vacante, Filippo Drago, and Antonio Biondi. 2012. "Potential role of probiotics on colorectal cancer prevention." *BMC Surgery* 12(1):S35.

Wang, Li-Xin, Kai Liu, Da-Wei Gao, and Ji-Kui Hao. 2013. "Protective effects of two *Lactobacillus plantarum* strains in hyperlipidemic mice." *World Journal of Gastroenterology: WJG* 19(20):3150.

Xie, Ning, Yi Cui, Ya-Ni Yin, Xin Zhao, Jun-Wen Yang, Zheng-Gen Wang, Nian Fu, Yong Tang, Xue-Hong Wang, and Xiao-Wei Liu. 2011. "Effects of two lactobacillus strains on lipid metabolism and intestinal microflora in rats fed a high-cholesterol diet." *BMC Complementary and Alternative Medicine* 11(1):53.

Xiong, Zhi-Qiang, Qiao-Hui Wang, Ling-Hui Kong, Xin Song, Guang-Qiang Wang, Yong-Jun Xia, Hui Zhang, Yong Sun, and Lian-Zhong Ai. 2017. "Improving the activity of bile salt hydrolases in *Lactobacillus casei* based on in silico molecular docking and heterologous expression." *Journal of Dairy Science* 100(2):975–80.

Yadav, Hariom, Shalini Jain, and P. R. Sinha. 2007. "Antidiabetic effect of probiotic dahi containing *Lactobacillus acidophilus* and *Lactobacillus casei* in High Fructose Fed Rats." *Nutrition* 23(1):62–68.

Yadav, Hariom, Shalini Jain, and Pushpalata Ravindra Sinha. 2008. "Oral administration of dahi containing probiotic *Lactobacillus acidophilus* and *Lactobacillus casei* delayed the progression of streptozotocin-induced diabetes in rats." *Journal of Dairy Research* 75(2):189–95.

Yin, Ya-Ni, Qiong-Fen Yu, Nian Fu, Xiao-Wei Liu, and Fang-Gen Lu. 2010. "Effects of four bifidobacteria on obesity in high-fat diet induced rats." *World Journal of Gastroenterology: WJG* 16(27): 3394.

Yun, S. I., H. O. Park, and J. H. Kang. 2009. "Effect of *Lactobacillus gasseri* BNR17 on blood glucose levels and body weight in a mouse model of type 2 diabetes." *Journal of Applied Microbiology* 107(5):1681–86.

Zhang, Yu-Jie, Sha Li, Ren-You Gan, Tong Zhou, Dong-Ping Xu, and Hua-Bin Li. 2015. "Impacts of gut bacteria on human health and diseases." *International Journal of Molecular Sciences* 16(4):7493–7519.

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