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Kefir and Gut microbiota modulation: Implications for human health and chronic disease management: A Review

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Abstract

Over the past several decades, there have been changes in the global and Indian health and illness patterns, with a rise in the prevalence of chronic non-communicable diseases. Alterations in the makeup of the gut microbiota can both aid in the treatment of certain conditions and play a role in their development. Given its ability to modulate the gut microbiota, the ingestion of fermented foods with probiotic qualities, like kefir, stands out in this context. Since kefir can be promoted as a natural beverage with microbes that promote health and has been growing in popularity throughout India, there is growing interest in using it commercially. Additionally, considering the financial status of this population, which emphasizes the need for illness prevention at the expense of its treatment, the use of these drinks appears to be even more pertinent in India. Kefir's potential benefits against obesity, diabetes mellitus, liver disease, cardiovascular disease, immunological diseases, and neurological illnesses are covered in this narrative review. Kefir's peptides, bioactive substances and strains have the power to alter the composition of the gut microbiota, intestinal permeability and low-grade inflammation, all of which may have positive health effects. As a potential preventative measure for metabolic disorders, kefir can also have an impact on the control of organism homeostasis, directly affecting the gut-brain axis. To standardize these bioactive substances and clarify the processes behind the relationship between kefir and gut microbiota modification, more research is required. However, kefir appears to be a potential strategy for managing and preventing microbiota-related disorders throughout India and the rest of the world because of its stated advantages, low cost, and ease of preparation.

Keywords: Kefir, Gut microbiota, probiotics, functional foods, bioactive compounds, chronic diseases

Introduction

Intestinal microbiota alterations have been linked to a significant shift in worldwide health in recent decades (Collen, 2016) ^[10]. The development of human diseases like allergies, neurological disorders, and obesity is thought to be significantly influenced by the intestinal microbiota that is formed during childhood (Butel, 2018) ^[5]. This suggests that the intestinal microbiota plays a critical role in the advancement of novel health maintenance strategies. The human digestive system is home to a collection of microorganisms known as the intestinal microbiota, which includes helminths, bacteria, fungus, and archaea, among others (Dominguez, 2019) ^[12]. According to Thursby (2017) ^[39], it is thought to consist of over 1014 microorganisms in a healthy adult. The World Gastroenterology Organization states that the majority of the bacteria in the stomach and duodenum are lactobacilli and streptococci. The large intestine has the highest concentration, with around 1012 cells per gram, particularly anaerobic microbes, whereas the jejunum and ileum contain an intermediate quantity (104-107 cells per gram), (Cani, 2019) ^[6]. The relevance of the gut microbiota in human health is further shown by this microbial variety, which shows that bacteria are not always harmful or the source of disease, as was previously believed. Conversely, it is becoming more evident that they co-evolved with their human hosts and that microbes can play a significant role in preserving health (Milani, 2017) ^[26]. Fermented foods are significant in this context, since the significance of bacteria for human health has been understood for more than 150 years

(Smolyansky, 2010) ^[36]. Food has evolved through fermentation because of its improved shelf life and conservation potential, taste development, and health advantages (Kok, 2018) ^[22].

Beneficial bacteria found in fermented meals can operate in the gut and can withstand the digestive system. Fermented meals can alter the intestinal microbiota's composition, enhance the regulation of intestinal permeability, strengthen the barrier function, activate digestive enzymes, and aid in the synthesis of vitamins and short-chain fatty acids (Bell, 2018) ^[2]. Bioactive substances and peptides with prebiotic, antibacterial, anti-inflammatory, and antioxidant properties are also present in fermented meals. Consuming fermented foods has therefore been shown to improve immunity and overall health, alleviate the symptoms of lactose intolerance, and lower the chance of developing certain diseases, including metabolic syndrome, cardiovascular disease, diabetes, and cancer (Sanlier, 2019) ^[32]. One such fermented food is probiotics. Probiotics are defined as live bacteria that, when consumed, provide positive health effects (Hill, 2014) ^[18].

Lactobacillus and *Bifidobacteria* are significant species of lactic acid bacteria utilized as probiotics, with evidence of their significance in human health dating back to Elie Metchnikoff's research in 1907 (Smolyansky, 2010) ^[36]. The use of probiotics also stands out in the case of diseases brought on by changes in the intestinal microbiota because they can help maintain the intestinal microbiota's homeostasis through the production of mucin, competition for pathogen adherence, inflammation control, pH change, cytokine production, and immunomodulatory and anti-inflammatory properties, all of which lead to improved health (Kim, 2019) ^[21]. A single culture made up of yeast and bacteria that produce lactic and acetic acids produces kefir, a fermented product (Bengoa, 2019) ^[4]. Because of its bioactive components, such as exopolysaccharides, conjugated fatty acids, and peptidases, it is an inexpensive meal that is available to the general public, easy to handle, and has a lot of functional potential (Bengoa, 2019) ^[4]. Adult people and animals do not appear to have any adverse consequences from consuming kefir. Kefir made with whole milk has a high cholesterol content and can cause allergic reactions in people who are intolerant to lacteal proteins (Table 2). These side effects can be prevented by substituting water and sugar for the milk matrices, which further supports the idea that kefir has no negative effects (Farag, 2020) ^[13].

In Sprague Dawley rats with diet-induced obesity, kefir peptides can enhance obesity-related indices. By downregulating the fatty acid synthase enzyme and increasing the phosphorylated acetyl coenzyme A carboxylase (p-ACC)

protein, as well as increasing lipid oxidation and the expression of AMP-activated protein kinase (p-AMPK), peroxisome proliferator-activated receptor alpha (PPAR- α), and carnitine palmitoyltransferase 1 (CPT1), they inhibit lipogenesis. They also decrease the inflammatory response and oxidative modulation, including transforming growth factor beta (TGF- β), interleukin1 beta (IL-1 β), and tumor necrosis factor alpha (TNF- α) cytokines (Tung, 2018) ^[41], (Table 1). Furthermore, kefir-derived strains of *Lactobacillus harbinensis*, *Lactobacillus paracasei*, and *Lactobacillus plantarum* contribute to intestinal mucosa adhesion, antimicrobial resistance, and tolerance to bile acids and salts, suggesting that the bacteria present in kefir can withstand the gastrointestinal tract and have probiotic and antioxidant properties (Talib, 2019) ^[37]. In light of the aforementioned, we will talk about research involving both people and animals that has documented the use of kefir and its bioactive ingredients in the management of illnesses marked by changes in the gut flora.

Kefir in other nations

Long-lasting illnesses having several etiologies, such as genetic, psychological, environmental, and behavioral components, are referred to as non-communicable diseases. Diabetes, cancer, and cardiovascular disease are a few instances of what are commonly referred to as chronic illnesses (Forouzanfar, 2016) ^[16]. Yogurt intake is linked to a decrease in weight gain, a decreased risk of obesity, and a lower risk of cardiovascular illnesses, all of which are linked to the prevention of chronic non-communicable diseases (Kovalskys, 2019) ^[23]. Fermented milks have intriguing nutritional benefit since they help break down lactose and are a good source of protein and calcium (Fisberg, 2015) ^[15].

Yogurt consumption has been rising among higher-income populations in Brazil, where it is usually consumed outside the home. Similar trends are seen in India, where consumption is primarily among the youngest and most affluent individuals (Kovalskys, 2019) ^[23]. Thus, we emphasize the use of milk kefir, another fermented product, as a substitute for yogurt intake. It has health advantages because of its probiotic content and the presence of bioactive substances (Rosa, 2017) ^[31].

Researchers from India have also investigated the use of kefir as a disease treatment, finding that drinking this fermented beverage improved obesity-related parameters in animal models and decreased preneoplastic lesions in the intestinal colon (Reis, 2019) ^[30]. It has also been shown that people with osteoporosis and lactose intolerance have a higher quality of life (Dinamarca, 2015) ^[11].

Table 1: Key findings from research on kefir interventions

Population	Disease/Condition	Kefir Consumption	Main Outcomes
Humans	Metabolic syndrome	180 mL/day, 12 weeks	↑ Actinobacteria, fasting insulin, HOMA-IR; ↓ TNF- α , IFN- γ , systolic & diastolic BP
Women (25-45 yrs)	Obesity	2 servings/day, 8 weeks	↓ serum lipoproteins (TC, LDL, Non-HDL, TC/HDL, LDL/HDL)
Adults (35-65 yrs)	Type 2 diabetes mellitus	600 mL/day probiotic milk (<i>L. casei</i> , <i>L. acidophilus</i> , <i>Bifidobacteria</i>), 8 weeks	↓ HbA1C
Post-menopausal women	Sleep quality, QoL, depression	500 mL/day (250 mL morning + evening), 30 days	Improved MENQOL, BDI, WHIIRS scores
Humans	Obesity / intestinal integrity	300 mL/day, 3 weeks	↓ zonulin, glucose, HDL cholesterol, appetite; ↑ positive mood

Men	Hypercholesterolemia	500 mL/day, 2 × 4 weeks	↑ fecal SCFAs (isobutyric, isovaleric, propionic), bacterial content
C57BL/6 female mice	Diet-induced obesity	100 µL/day by gavage, 12 weeks	↓ weight gain, plasma cholesterol, hepatic triglycerides
Sprague Dawley rats	Hepatic steatosis (HFD)	10 ⁷ -10 ¹⁰ CFU <i>L. mali</i> APS1/day, 12 weeks	↓ HOMA index, hepatic lipids; ↑ GLP-1, antioxidant activity, butyrate, Bacteroidetes/Firmicutes
C57BL/6J mice	Obesity (HFD)	0.1-0.2% kefir powder diet, 8 weeks	↓ body weight, fat pad, adipocyte size, adipogenesis/lipogenesis genes, inflammation, hepatic TAG, serum TG, LDL; improved liver enzymes
Wistar rats	Hepatotoxicity	Not informed	Normalized AST, ALT, bilirubin, cholesterol
Female BALB/c mice	Obesity	0.2 mL/day orally, 3 weeks	↓ Firmicutes, Proteobacteria, Enterobacteriaceae, F/B ratio; ↑ Bacteroidetes, <i>Lactobacillus</i> , Lactococcus, yeast; suppressed pathogen growth
Male C57BL/6 mice	Obesity + NAFLD (HFD)	0.2 mL saline with 2×10 ⁸ CFU (<i>L. kefir</i> DH5, <i>L. kefir</i> DH7, <i>L. mesenteroides</i> DH4), 6 weeks	↓ body weight, adipose tissue, TG, LDL, hepatic steatosis, adipocyte size; modulated microbiota; ↑ PPARα, FABP4, CPT1 expression

Intestinal Microbiota Modulation

The bacteria, helminths, fungus, archaea, and other microorganisms that make up the intestinal microbiota can be either balanced or out of balance (Dominguez, 2019) [12]. In the first scenario, called eubiosis, the microbiota is flexible enough to maintain its equilibrium by tolerating minor alterations that may be brought on by the environment, food, or water intake. However, dysbiosis, or imbalance, results from significant changes such the growth or translocation of a particular bacterial group, colonization by pathogenic bacteria, the use of antibiotics, and lifestyle modifications (Weiss, 2017) [42].

Modification of the intestinal flora led to improvements in metabolism and body weight loss in a long-term research evaluating obese individuals after bariatric surgery. The phyla Firmicutes, Fusobacteria, and Verrucomicrobia varied among bariatric surgery patients compared to those of normal weight. Additionally, *Akkermansia muciniphila* was found during bariatric surgery. Its presence suggests that the expression of healthy metabolism markers has improved. It is a species that

is positively associated with lipid metabolism and negatively associated with adipose tissue inflammation and circulating levels of glucose, insulin, leptin, and triglycerides (Palmisano, 2020) [27]. Bile acids also possess antimicrobial properties. Additionally, by modulating inflammatory processes, signaling energy metabolism events, and acting as a biological detergent, they contribute to the development of diseases like obesity and gastrointestinal disorders that are linked to alterations in intestinal microbiota (Joyce, 2016) [20]. Therefore, there is a two-way relationship where bile acid production is influenced by gut microbiota and intestinal modulation performance is influenced by bile acid production. According to Bellikci-Koyu *et al.* (2019) [3], who studied people with metabolic syndrome who were given kefir supplements for 12 weeks, kefir drinking also causes changes in the gut microbiota in humans (Table 1). Following the intervention, the kefir-consuming group showed a notable rise in Actinobacteria and alterations in the genera of the phyla Bacteroidetes and Firmicutes.

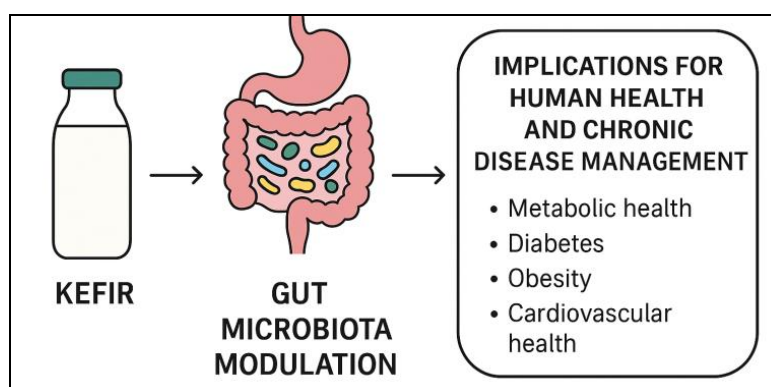


Fig 1: Kefir, the Gut Microbiota Ally: A Natural Path to Better Health

This intestinal modulation affects metabolic parameters, which are indicative of metabolic syndrome. It shows improvement in insulin resistance index (HOMA-IR) and fasting insulin, as well as a decrease in pro-inflammatory cytokines like interferon-gamma (IFN-γ) and TNF-α, as well as in systolic and diastolic pressure (Table 2). Furthermore, a relationship between these variables and the intestinal microbiota was found: the relative abundance of Firmicutes and Proteobacteria was favorably connected with body weight growth and BMI, whereas the relative abundance of Clostridium was negatively connected. Bellikci-Koyu *et al.* (2019) [3] discovered correlations between the gut microbiota's composition and blood pressure, insulin, homocysteine, LDL cholesterol, waist circumference, and fat mass.

Numerous variables, including age, sex, the initial establishment of the intestinal microbiota, food intake (particularly fiber consumption), lifestyle, and medication usage, particularly antibiotic use, can change the makeup of the human gut microbiota (Zhuang, 2019) [43]. Thus, Bellikci-Koyu *et al.* (2019) [3] findings are pertinent and open the door for more research demonstrating how kefir might alter the human gut microbiota in people with metabolic syndrome.

Obesity and Kefir

A increased risk of obesity in infancy and adulthood is linked to dysbiosis and other factors that influence the establishment of the gut microbiota in children, such as formula feeding or cesarean delivery (Ficara, 2020) [14]. Since drugs can change

the makeup of the intestinal microbiota and cause a dysbiotic condition, children treated with antibiotics particularly macrolides, amoxicillin, cefdinir, vancomycin and tetracyclines (Principi, 2016) ^[29] had a greater prevalence of obesity (Kim, 2019) ^[21]. The association between intestinal microbiota and obesity is further supported by the fact that the intestinal microbiota is clearly different in eutrophic and obese circumstances (Hou, 2017) ^[19]. Therefore, the gut microbiota can potentially have an impact on obesity and overweight, which are defined by an excess or buildup of body fat and a corresponding rise in health risk (Schetz, 2019) ^[33].

By blocking enzymes involved in the breakdown of fats and carbs, kefir may help prevent obesity by reducing the amount of energy released. For instance, Tiss *et al.* (2020) ^[40] assessed the activity of lipase and α -amylase *in vitro* and in the gut and pancreas of rats that were obese due to a high-calorie diet using a fermented beverage with kefir made from soymilk.

Two varieties of traditional kefir lowered weight gain and plasma cholesterol, while one kind decreased the deposit of hepatic triglycerides. These findings suggest that traditional kefir may help regulate obesity by improving metabolic function. The pH, viscosity, and microbiological makeup of fermented beverages all differ, which accounts for the discrepancy in the results.

In C57BL/6 mice with nonalcoholic fatty liver disease and obesity brought on by a high-fat diet, Kim *et al.* (2017) ^[24] assessed the anti-obesity benefits of kefir (Table 1). By lowering intestinal lumen cholesterol and up regulating PPAR α in adipose tissue, the *Lactobacillus kefir* DH5 strain

was able to lower body weight, adipose tissue, and plasma lipid markers. PPAR α is a transcription factor that plays a role in lipid oxidation and the subsequent metabolism of fats and carbohydrates. Its activation is linked to an increase in inflammation and hepatic steatosis (Pawlak, 2015) ^[28].

Furthermore, as compared to the animals that were not supplemented, the animals that ingested this strain showed a change in the intestinal microbiota's composition, with less Proteobacteria and Enterobacteriaceae. According to these findings, *Lactobacillus kefir* DH5 may be used as a probiotic strain to treat obesity (Kim, 2017).

The favorable benefits of exopolysaccharides obtained from kefir grains were assessed by Lim *et al.* (2017) ^[24], who demonstrated that the viscosity of the exopolysaccharides produced by the bacteria present in kefir may be associated to these effects. The authors found that by inhibiting adipogenesis, exopolysaccharides might reduce obesity *in vitro*. Additionally, there were *in vivo* decreases in plasma Very Low Density Lipoprotein Cholesterol (VLDL), adipose tissue weight, and body weight growth. Both the presence of bacterial metabolites and the product's viscosity, which suppresses appetite and lowers calorie intake as well as glucose and fat absorption, were cited as explanations for these *in vivo* outcomes.

Additionally, the availability of kefir exopolysaccharides was able to boost Akkermansia abundance. By altering the intestinal microbiota, altering inflammatory conditions in adipose tissue, and improving metabolic parameters such as body weight, adiposity, inflammation markers, and biochemical parameters, *Akkermansia muciniphila* exhibits significant potential for the treatment of obesity.

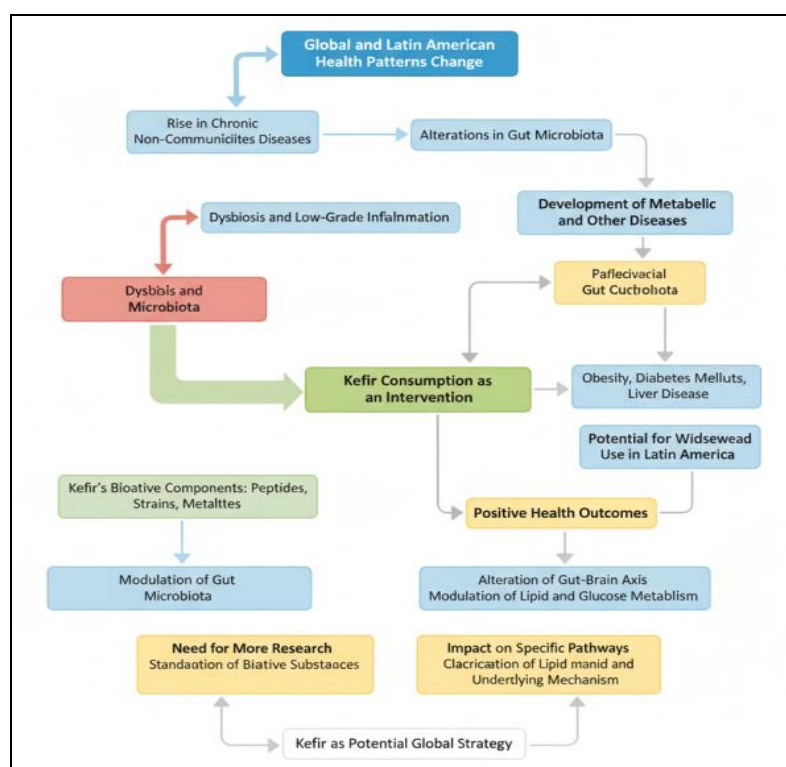


Fig 2: Flowchart of Kefir's impact on health and disease prevention

Diabetes Mellitus and Kefir

Low-grade chronic inflammation is linked to the development of diabetes mellitus. This inflammation is promoted by changes in intestinal permeability, which are supported by an imbalance in the intestinal microbiota. This results in resistance to systemic insulin, which in turn causes the

development of diabetes (Cani, 2012) ^[7]. Furthermore, the development of diabetes is linked to variables that influence the establishment of the intestinal microbiota, including maternal health during pregnancy, cesarean delivery, antibiotic usage throughout infancy, and intestinal dysbiosis during childhood. Whole milk kefir, administered by gavage

for 10 weeks, was found to be effective in lowering insulin resistance in a trial involving Wistar rats with monosodium glutamate-induced metabolic syndrome. These outcomes were ascribed to the animals' consumption of calcium and the beneficial substances created when kefir fermented. Moreover, kefir enhanced absorption of glucose by muscle cells, which led to the decrease of insulin resistance (Rosa, 2016) [31].

A strain of *Lactobacillus* Mali APS1 that was isolated from kefir grain has potential use in the management of diabetes. When given to mice on a high-fat diet, this strain was able to lower the HOMA index and blood glucose while raising the levels of butyrate and glucagon-like peptide (GLP-1), (Chen, 2018) [41]. The drop in the HOMA index implies glycemic management (Antunes, 2016) [1] and the rise in GLP-1 indicates control of hunger and possibly protection of pancreatic beta cells, which are insulin-producing cells, crucial for maintaining glycidic homeostasis (Meier, 2012) [25]. Furthermore, the decline in butyrate content as a feature of intestinal dysbiosis in diabetes is covered in a recent study. Consequently, these outcomes are favorable. Kefir has also been shown to help treat diabetes mellitus in people, according to a study that involved 60 diabetic patients between the ages of 35 and 65. The patients were split into two groups: the regular fermented milk group and the kefir probiotic group. For eight weeks, each group received 600 milliliters of the treatment drink daily. Following the study, patients who took kefir supplements showed reduced levels of glycated hemoglobin and fasting glucose compared to those who drank the other fermented beverage.

Kefir's probiotic makeup particularly that of *Lactobacillus* and *Bifidobacterium*, was thought to be responsible for the positive health effects it produced. These bacteria have a hypoglycemic effect because they increase the production of glucagon-like peptides and insulinotropic peptides, which increase muscle cell uptake of glucose. They also increase the production of hepatic glycogen, which uses the bloodstream glucose.

Liver and Kefir illnesses: Low-grade chronic inflammation

can arise due to intestinal microbiota-produced toxins and metabolic endotoxemia, or increased intestinal permeability. The connection between the intestinal microbiota and the development of liver illnesses is explained by this inflammatory situation, which triggers the activation of tolllike receptors and macrophages, resulting in hepatic and systemic inflammation (Cani, 2012) [17].

Consuming *Lactobacillus* kefir DH5 has a hepatoprotective effect in addition to its impact on obesity. The mice who ate this strain showed reduced lipid buildup and smaller fat cells under the microscope, and their livers looked comparable to those of the animals that did not eat a high-fat diet (Kim, 2017) [24].

Golli-Bennour *et al.* (2019) [17] also evaluated kefir's hepatoprotective potential by examining its impact on hepatotoxicity brought on by the herbicide deltamethrine. When compared to control groups that did not receive the pesticide, the investigators found that deltamethrine changed liver markers in Wistar rats, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), bilirubin, and cholesterol; however, these values decreased when kefir was consumed. Additionally, compared to the group that got only deltamethrine, the pesticide and kefir supply was able to raise the levels of catalase and superoxide dismutase while decreasing the levels of carbonylated protein and malondialdehyde. These problems with protein and lipid peroxidation are signs of oxidative stress and the pesticide's development of toxicity. Kefir, on the other hand, was able to reverse the inflammatory state and was unable to cause oxidative stress on its own.

The fatty liver of a rat given a high-fat diet was also used to investigate the effects of *Lactobacillus* Mali APS1, which was isolated from sweet kefir grains. The results showed a substantial decrease in weight, weight increase, hepatic lipid accumulation, and blood levels of AST and ALT. This strain suppressed the advancement of hepatic steatosis by altering the makeup of the intestinal microbiota, lowering the percentage of bacteria linked to non-alcoholic liver disorders, and controlling lipid metabolism and the oxidative stress response (Chen, 2018) [41].

Table 2: Health benefits of kefir consumption in relation to chronic diseases

Health Aspect	Mechanism/Role of Kefir	Implication in Chronic Diseases
Gut microbiota modulation	Increases beneficial bacteria (<i>Lactobacillus</i> , <i>Bifidobacterium</i>) and reduces pathogens	Improves gut health, reduces risk of obesity and diabetes
Anti-inflammatory effect	Suppresses pro-inflammatory cytokines, enhances immune response	Helps in prevention of metabolic syndrome and cardiovascular diseases
Antioxidant activity	Bioactive peptides and polyphenol metabolism neutralize free radicals	Protects against oxidative stress-related disorders
Lipid metabolism	Improves cholesterol profile (↓LDL, ↑HDL)	Reduces risk of atherosclerosis and heart disease
Glucose metabolism	Enhances insulin sensitivity and regulates blood sugar	Prevents and manages type 2 diabetes

Kefir and changes in the cardiovascular

Intestinal dysbiosis associated with obesity is also linked to cardiovascular disorders (Zhuang, 2019) [43]. Furthermore, alterations in the gut flora may result in the synthesis of substances such trimethylamine N-oxide (TMAO), which raises the risk of cardiovascular disorders.

Assessed the impact of kefir peptides on ApoE mice that had atherosclerosis brought on by a high-fat diet. Following a 12-week intervention, kefir consumption resulted in less lipid deposition at the aortic root, a decrease in the progression of atherosclerotic lesions, and a suppression of the inflammatory immune response by lowering oxidative stress, macrophage accumulation, and the release of cytokines such as TNF- α and

IL-1 β . Additionally, kefir inhibited monocyte endothelial adhesion, which slowed the progression of the atherosclerotic lesion. These findings suggest that kefir drinking may be helpful in both preventing and treating atherosclerosis.

Dyslipidemia is a risk factor for the development of cardiovascular illnesses. In this way, the host's gut microbiota is less diverse and is more susceptible to dysbiosis. In other words, there is a higher likelihood of inflammation and alterations in intestinal permeability, which might have detrimental effects on the host's health (Schoeler, 2019) [35].

Changes in the synthesis of bile acids and short-chain fatty acids have been noted in dyslipidemia. As metabolite substrates, short-chain fatty acids take role in the synthesis of

cholesterol, lipogenesis, gluconeogenesis, and energy. Conversely, the farnesoid X receptor, which is similarly linked to the onset of obesity, may bind to main bile acids. Both factors contribute to changes in intestinal microbiota and lipid metabolism, suggesting that altering intestinal microbiota might be a treatment option to avoid dyslipidemia. One potential therapy for dyslipidemia is kefir. In mice given an obesogenic diet, Choi *et al.* (2017) ^[9] found that kefir inhibited the rise of lipid parameters, suggesting that kefir worked via blocking intestinal absorption of lipids (Table 1). Similar to the control group that drank low-fat milk, the lipid profile of individuals improved after consuming 250 ml of kefir drink for eight weeks. The reduction in body weight that was attained through kefir consumption and the alterations in the intestinal microbiota that resulted in a rise in the production of bile acids and short-chain fatty acids were linked to this improvement in the lipid profile. It is important to note, though, that the quantity of kefir provided and the duration of the intervention are crucial for achieving the intended outcome for improving dyslipidemia.

Immunity and Kefir

Since the intestinal microbiota is a component of the immune system, its proper growth during infancy is essential for the whole development of the infant, particularly during the first few months of life when the rest of the immune system is still developing. In this regard, preterm infants may have immunological, respiratory, and neurological system immaturity, indicating a potential correlation between them. Furthermore, the immune system and intestinal microbiota work together to maintain a state of non-inflammatory homeostasis. When intestinal dysbiosis occurs, the immune system is activated, which alters the host's immunity. These alterations may hinder the innate immune system's development or result in autoimmune conditions like type 1 diabetes (Weiss, 2017) ^[42].

Conclusion

Systemic activity is demonstrated by changes in the gut microbiota, such as dysbiosis or metabolic endotoxemia, which permit the development of low-grade chronic inflammations that impact the entire body. Therefore, altering the gut microbiota stands out as a useful method for both illness prevention and therapy. Because of its low cost, ease of preparation, and microbiological composition, which is rich in bioactive compounds, metabolites, and peptides, the use of fermented foods with probiotic activity is a nutritional alternative to drug treatments and kefir. It also has no negative effects on consumption in humans or animals. In addition, promising outcomes such as glycemic management, immunomodulation, hypercholesterolemia, and antihypertensive effects are anticipated. Further research on the molecular pathways and microbes involved is necessary, though, as are more carefully monitored human intervention studies.

Conflict of Interest Statement

The authors declare no conflict of interest. This review was conducted independently, and no financial support, personal relationships, or affiliations could have appeared to influence the content or conclusions presented in this manuscript.

Conflict of Interest

Not available

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