Microbial Communities in Home-Made and Commercial Kefir

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Kefir is a popular traditional fermented dairy product in many countries. It has a complex and symbiotic culture made up of species of the genera *Leuconostoc*, *Lactococcus*, and *Acetobacter*, as well as *Lactobacilluskefiranofaciens* and *Lentilactobacillus kefiri*. Though *kefir* has been commercialized in some countries, people are still traditionally preparing *kefir* at the household level. *Kefir* is known to have many nutritious values, where its consistent microbiota has been identified as the main valuable components of the product. Type 2 diabetes mellitus (T2DM) is a common diet-related disease and has been one of the main concerns in the world's growing population.

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1. Microbial Composition of Home-Made and Commercial *Kefir*

The microbial diversity of kefir has been thoroughly studied using culture-dependent techniques; however, in recent times, due to the application of sequence-based taxonomical tools, its microbial diversity has revealed more interesting findings among the homemade and the commercial varieties of kefir [1]. The widely reported microbiota present in *kefir* includes bacteria (lactic-acid bacteria, acetic-acid bacteria) and eukaryota (yeast and fungi) [2] make it a probiotic food product with a good source of probiotic microorganisms. Overall, the predominance of *Bacillota* (basonym: *Firmicutes*) [3] has been reported through various studies in both home-made and commercial *kefir* products [4], whereas the predominance of phylum *Actinomycetota* (basonym: *Actinobacteria*) [3] in the traditionally prepared *kefir* of Mexico has also been reported [5]. Metagenomics-based studies of *kefir* microbiota have been mostly studied using targeted amplicon sequencing and shotgun metagenomics [6][7][8][9][10]. So far, about 23 species (bacteria and eukaryota) have been reported from commercial *kefir* samples, among which *Streptococcus thermophilus*, *Lactococcus lactis*, and *Leuconostoc mesenteroides* are the main predominant species [9]. Among eukaryota, *Debaryomyces hansenii* and *Kluyveromyces marxianus* are the only two yeast species to have been reported [10]. Similarly, among the home-made *kefir* samples, the main predominant species belong to the lactic-acid bacterial group, where *Lactobacillus kefiranofaciens* and *Lentilactobacillus kefiri* have been reported as the most abundant species through metagenomics (both amplicon and shotgun) studies [11]. Interestingly, in some varieties of *kefir* of Turkey, the predominance of *Bifidobacterium longum is also reported* [12]. To date, about 66 species (bacteria and eukaryota) have been reported from metagenomics studies from home-made *kefir* samples, among which lactic-acid bacteria and acetic-acid bacteria are predominant [5][6][7][9][10][11][12][13][14][15][16][17][18][19]. Eukaryota (yeast and fungi) is also present to a significant degree in the home-made *kefir,* as compared to that of commercial *kefir*. However, homemade *kefir* shows the presence of many unwanted contaminants that would hamper the quality of the samples. From the above research studies, only the species *viz*., *Lactococcus lactis*, *Leuconostoc mesenteroides*, *Streptococcus thermophilus*, and *Acinetobacter* sp. are found to be shared among the homemade and commercial *kefir,* and only one yeast *Kluyveromyces marxianus* has been reported from both the *kefir* varieties.

2. Hypoglycemic Properties of *Kefir*

Type 2 diabetes mellitus (T2DM) is a serious long-term disorder [20] that is primarily caused due to defective insulin secretion by pancreatic β-cells and the inability of insulin-sensitive tissues to respond to insulin [21], preventing the proper circulation of glucose for cell uptake [22]. It has been reported that some fermented milk products have hypoglycemic properties [23][24]. Biochemically, T2DM is mainly associated with glucose and lipid absorption in the human gut and is one of the main therapeutic measures to control the enzymes associated with these phenomena, such as lipid and carbohydrate hydrolyzing enzymes *viz.,* lipases, and α-amylases [25]. Subsequently, it has also been shown that upon kefir administration, the reduction of α-amylase and lipases was significant [26]. *Kefir* exhibits a negative effect on α-amylase, one of the important enzymes that is regulated in the type two diabetes pathway [26], and reduces insulin resistance [27]. The intake of *kefir* has been demonstrated to have a great impact in the treatment of type 2 diabetes and increases the life span in treated rats [28][29] via the mechanisms that will be mentioned in following sections. Many probiotic bacteria have been shown to help ameliorate type 2 diabetes disorder through various means such as reducing insulin resistance and improving glucose homeostasis [30]. Short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate have been shown to be important targets in the treatment of type 2 diabetes [31], which has also been reported in *kefir* [19], showing positive colonic and immune modulation [32]. The MK-9 variant of menaquinone (Vitamin K_2) has been detected in *kefir* [33], which plays a role in improving insulin resistance and reducing type 2 diabetes by means of its anti-inflammatory and lipid-lowering effects [34]. Some studies on animal models and human clinical trials have been conducted to validate the hypoglycemic properties of both homemade and commercial *kefir*, which are reviewed below.

3. Animal Studies

Few animal models were investigated to validate the hypoglycemic properties of *kefir*. The blood glucose level of group 4 of rats was found to be lower than that of group 3 ($p < 0.001$) after feeding with *kefir,* indicating better control of oxidative stress and a decrease in the progression of diabetic nephropathy [35]. In another study, rats were divided into three different groups (the control group, fructose group, and fructose and *kefir* group), and fructose was given for 15 weeks, while *kefir* (1 mL/100 g/day) was given only for the last 6 weeks of the duration [36]. *Kefir* treatment improved insulin signaling in the liver via insulin receptor substrate 1 (IRS-1) and phospho-endothelial nitric oxide synthase (peNOS) [36]. The effect of *kefir* on metabolic syndrome was investigated [37]. Rats were divided into three different groups (negative control, without metabolic syndrome), positive control (with metabolic syndrome), and *kefir* group (with metabolic syndrome) in a study. The fasting insulin, glucose, and HOMA-β values of the *kefir* group were found to be lower than in the positive control group. When compared before and after the study, the highest decrease in the AUC value was observed in the group fed with *kefir* [37]. The effects of *kefir* on oxidative stress in diabetic animals were studied, and it was observed that *kefir* may contribute to the better control of glycemia and oxidative stress, indicating its consumption to delay the progression of diabetic complications [38].

Based on an animal study, the effect of the combination of goat and soy milk on lipid profile, plasma glucose, glutathione peroxidase (GPx) activity, and the improvement of pancreatic β-cell in diabetic rats was noted [39]. It was found that *kefir* combination can maintain the serum triglyceride, decrease plasma glucose, increase GPx activity, and improve pancreatic β-cells [39]. The effects of the consumption of a prebiotic (catechin-rich wine grapeseed flour, GSF) and a probiotic (*Lactobacillus kefiri* DH5) by obese mice on their hepatic steatosis were studied, and it was observed that the amelioration of high fat-induced hepatic steatosis after the consumption of GSF and *Lentilactobacillus kefiri* was partially mediated via the alteration of cecum propionate and intestinal permeability [40]. Nurliyani et al. (2022) conducted another experiment to determine the effect of goat milk *kefir* supplemented with synbiotic *kefir* and goat milk *kefir* without probiotic *kefir* on blood glucose, haemoglobin A1c (HbA1c), and insulin-producing cells in rats fed a high-fat and high-fructose (HFHF) diet. There was a decrease in the HbA1c level of the group receiving symbiotic *kefir,* which improved the health of rats fed an HFHF diet [41].

References

1. de Melo Pereira, G.V.; de Carvalho Neto, D.P.; Maske, B.L.; De Dea Lindner, J.; Vale, A.S.; Favero, G.R.; Viesser, J.; de Carvalho, J.C.; Góes-Neto, A.; Soccol, C.R. An updated review on bacterial community composition of traditional fermented milk products: What next-generation sequencing has revealed so far? Crit. Rev. Food Sci. Nutr. 2022, 62, 1870–1889.
2. Kim, D.-H.; Jeong, D.; Kim, H.; Seo, K.-H. Modern perspectives on the health benefits of kefir in next generation sequencing era: Improvement of the host gut microbiota. Crit. Rev. Food Sci. Nutr. 2019, 59, 1782–1793.
3. Oren, A.; Garrity, G.M. Valid publication of the names of forty-two phyla of prokaryotes. Int. J. Syst. Evol. Microbiol. 2021, 71, 005056.
4. Kalamaki, M.S.; Angelidis, A.S. High-throughput, sequence-based analysis of the microbiota of Greek kefir grains from two geographic regions. Food Technol. Biotechnol. 2020, 58, 138.
5. Tenorio-Salgado, S.; Castelán-Sánchez, H.G.; Dávila-Ramos, S.; Huerta-Saquero, A.; Rodríguez-Morales, S.; Merino-Pérez, E.; Roa de la Fuente, L.F.; Solis-Pereira, S.E.; Pérez-Rueda, E.; Lizama-Uc, G. Metagenomic analysis and antimicrobial activity of two fermented milk kefir samples. MicrobiologyOpen 2021, 10, e1183.

6. Biçer, Y.; Telli, A.E.; Sönmez, G.; Turkal, G.; Telli, N.; Uçar, G. Comparison of commercial and traditional kefir microbiota using metagenomic analysis. Int. J. Dairy Technol. 2021, 74, 528–534.
7. Kazou, M.; Grafakou, A.; Tsakalidou, E.; Georgalaki, M. Zooming into the microbiota of home-made and industrial kefir produced in Greece using classical microbiological and amplicon-based metagenomics analyses. Front. Microbiol. 2021, 12, 621069.
8. Kumar, M.R.; Yeap, S.K.; Mohamad, N.E.; Abdullah, J.O.; Masarudin, M.J.; Khalid, M.; Leow, A.T.C.; Alitheen, N.B. Metagenomic and phytochemical analyses of kefir water and its subchronic toxicity study in BALB/c mice. BMC Complement. Med. Ther. 2021, 21, 1–15.
9. Yusuf, B.; Gürkan, U. Analysis of the kefir and koumiss microbiota with the focus on certain functional properties of selected lactic-acid bacteria. Mljekarstvo: Časopis za unaprjeđenje proizvodnje i prerade mlijeka 2021, 71, 112–123.
10. Yegin, Z.; Yurt, M.N.Z.; Tasbasi, B.B.; Acar, E.E.; Altunbas, O.; Ucak, S.; Ozalp, V.C.; Sudagidan, M. Determination of bacterial community structure of Turkish kefir beverages via metagenomic approach. Int. Dairy J. 2022, 129, 105337.
11. Zeng, X.; Wang, Y.; Jia, H.; Wang, Z.; Gao, Z.; Luo, Y.; Sheng, Q.; Yuan, Y.; Yue, T. Metagenomic analysis of microflora structure and functional capacity in probiotic Tibetan kefir grains. Food Res. Int. 2022, 151, 110849.
12. Ilıkkan, Ö.K.; Bağdat, E.Ş. Comparison of bacterial and fungal biodiversity of Turkish kefir grains with high-throughput metagenomic analysis. LWT—Food Sci. Technol. 2021, 152, 112375.
13. Tu, C.; Azi, F.; Huang, J.; Xu, X.; Xing, G.; Dong, M. Quality and metagenomic evaluation of a novel functional beverage produced from soy whey using water kefir grains. LWT—Food Sci. Technol. 2019, 113, 108258.
14. Verce, M.; De Vuyst, L.; Weckx, S. Shotgun metagenomics of a water kefir fermentation ecosystem reveals a novel Oenococcus species. Front. Microbiol. 2019, 10, 479.
15. Sindi, A.; Badsha, M.B.; Ünlü, G. Bacterial populations in international artisanal kefirs. Microorganisms 2020, 8, 1318.
16. Tóth, A.G.; Csabai, I.; Maróti, G.; Jerzsele, Á.; Dubecz, A.; Patai, Á.V.; Judge, M.F.; Nagy, S.Á.; Makrai, L.; Bányai, K. A glimpse of antimicrobial resistance gene diversity in kefir and yoghurt. Sci. Rep. 2020, 10, 1–12.
17. de Almeida Brasiel, P.G.; Dutra Medeiros, J.; Barbosa Ferreira Machado, A.; Schuchter Ferreira, M.; Gouveia Peluzio, M.d.C.; Potente Dutra Luquetti, S.C. Microbial community dynamics of fermented kefir beverages changes over time. Int. J. Dairy Technol. 2021, 74, 324–331.
18. Guangsen, T.; Xiang, L.; Jiahu, G. Microbial diversity and volatile metabolites of kefir prepared by different milk types. CYTA—J. Food 2021, 19, 399–407.

19. Ibacache-Quiroga, C.; González-Pizarro, K.; Charifeh, M.; Canales, C.; Díaz-Viciedo, R.; Schmachtenberg, O.; Dinamarca, M.A. Metagenomic and Functional Characterization of Two Chilean Kefir Beverages Reveals a Dairy Beverage Containing Active Enzymes, Short-Chain Fatty Acids, Microbial β-Amyloids, and Bio-Film Inhibitors. Foods 2022, 11, 900.
20. Saeedi, P.; Petersohn, I.; Salpea, P.; Malanda, B.; Karuranga, S.; Unwin, N.; Colagiuri, S.; Guariguata, L.; Motala, A.A.; Ogurtsova, K. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res. Clin. Pract. 2019, 157, 107843.
21. Lima, J.E.; Moreira, N.C.; Sakamoto-Hojo, E.T. Mechanisms underlying the pathophysiology of type 2 diabetes: From risk factors to oxidative stress, metabolic dysfunction, and hyperglycemia. Mutat. Res. Genet. Toxicol. Environ. 2022, 874, 503437.
22. Berbudi, A.; Rahmadika, N.; Tjahjadi, A.I.; Ruslami, R. Type 2 diabetes and its impact on the immune system. Curr. Diabetes Rev. 2020, 16, 442.
23. Tamang, J.P.; Shin, D.-H.; Jung, S.-J.; Chae, S.-W. Functional properties of microorganisms in fermented foods. Front. Microbiol. 2016, 7, 578.
24. Sivamaruthi, B.S.; Kesika, P.; Prasanth, M.I.; Chaiyasut, C. A mini review on antidiabetic properties of fermented foods. Nutrients 2018, 10, 1973.
25. Vieira, C.P.; Cabral, C.C.; da Costa Lima, B.R.; Paschoalin, V.M.F.; Leandro, K.C.; Conte-Junior, C.A. Lactococcus lactis ssp. cremoris MRS47, a potential probiotic strain isolated from kefir grains, increases cis-9, trans-11-CLA and PUFA contents in fermented milk. J. Funct. Foods 2017, 31, 172–178.
26. Tiss, M.; Souiy, Z.; ben Abdeljelil, N.; Njima, M.; Achour, L.; Hamden, K. Fermented soy milk prepared using kefir grains prevents and ameliorates obesity, type 2 diabetes, hyperlipidemia and Liver-Kidney toxicities in HFFD-rats. J. Funct. Foods 2020, 67, 103869.
27. Peluzio, M.d.C.G.; Dias, M.d.M.e.; Martinez, J.A.; Milagro, F.I. Kefir and intestinal microbiota modulation: Implications in human health. Front. Nutr. 2021, 8, 638740.
28. Ostadrahimi, A.; Taghizadeh, A.; Mobasseri, M.; Farrin, N.; Payahoo, L.; Gheshlaghi, Z.B.; Vahedjabbari, M. Effect of probiotic fermented milk (kefir) on glycemic control and lipid profile in type 2 diabetic patients: A randomized double-blind placebo-controlled clinical trial. Iran. J. Public Health 2015, 44, 228.
29. Azizi, N.F.; Kumar, M.R.; Yeap, S.K.; Abdullah, J.O.; Khalid, M.; Omar, A.R.; Osman, M.A.; Mortadza, S.A.S.; Alitheen, N.B. Kefir and its biological activities. Foods 2021, 10, 1210.
30. Alihosseini, N.; Moahboob, S.; Farrin, N.; Mobasseri, M.; Taghizadeh, A.; Ostadrahimi, A. Effect of probiotic fermented milk (kefir) on serum level of insulin and homocysteine in type 2 diabetes patients. Acta Endocrinol. 2017, 13, 431.

31. Hu, J.; Lin, S.; Zheng, B.; Cheung, P.C. Short-chain fatty acids in control of energy metabolism. Crit. Rev. Food Sci. Nutr. 2018, 58, 1243–1249.
32. Calatayud, M.; Börner, R.A.; Ghyselinck, J.; Verstrepen, L.; Medts, J.D.; Abbeele, P.V.d.; Boulangé, C.L.; Priour, S.; Marzorati, M.; Damak, S. Water kefir and derived pasteurized beverages modulate gut microbiota, intestinal permeability and cytokine production in vitro. Nutrients 2021, 13, 3897.
33. Tarvainen, M.; Fabritius, M.; Yang, B. Determination of vitamin K composition of fermented food. Food Chem. 2019, 275, 515–522.
34. Dash, N.R.; Al Bataineh, M.T. Metagenomic analysis of the gut microbiome reveals enrichment of menaquinones (vitamin K2) pathway in diabetes mellitus. Diabetes Metab. J. 2021, 45, 77–85.
35. Kahraman, M.; Ertekin, Y.H.; Satman, İ. The Effects of Kefir on Kidney Tissues and Functions in Diabetic Rats. Probiotics Antimicrob. Proteins 2021, 13, 375–382.
36. Akar, F.; Sumlu, E.; Alçığır, M.E.; Bostancı, A.; Sadi, G. Potential mechanistic pathways underlying intestinal and hepatic effects of kefir in high-fructose-fed rats. Food Res. Int. 2021, 143, 110287.
37. Rosa, D.D.; Grześkowiak, Ł.M.; Ferreira, C.L.; Fonseca, A.C.M.; Reis, S.A.; Dias, M.M.; Siqueira, N.P.; Silva, L.L.; Neves, C.A.; Oliveira, L.L. Kefir reduces insulin resistance and inflammatory cytokine expression in an animal model of metabolic syndrome. Food Funct. 2016, 7, 3390–3401.
38. Punaro, G.R.; Maciel, F.R.; Rodrigues, A.M.; Rogero, M.M.; Bogsan, C.S.; Oliveira, M.N.; Ihara, S.S.; Araujo, S.R.; Sanches, T.R.; Andrade, L.C. Kefir administration reduced progression of renal injury in STZ-diabetic rats by lowering oxidative stress. Nitric Oxide 2014, 37, 53–60.
39. Nurliyani, A.; Harmayani, E.; Sunarti, S. Antidiabetic potential of kefir combination from goat milk and soy milk in rats induced with streptozotocin-nicotinamide. Korean J. Food Sci. Anim. Resour. 2015, 35, 847–858.
40. Kwon, J.H.; Lee, H.G.; Seo, K.H.; Kim, H. Combination of whole grapeseed flour and newly isolated kefir lactic-acid bacteria reduces high-fat-induced hepatic steatosis. Mol. Nutr. Food Res. 2019, 63, 1801040.
41. Nurliyani; Harmayani, E.; Sunarti. Synbiotic goat milk kefir improves health status in rats fed a high-fat and high-fructose diet. Vet. World 2022, 15, 173–181.