

Kefir, Gut Microbiota, and Metabolic Dysfunction in Polycystic Ovary Syndrome

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Abstract

Background: This dysbiotic state disrupts intestinal barrier integrity, leading to increased gut permeability “leaky gut”, which facilitates the translocation of microbial products such as lipopolysaccharides into the systemic circulation. Consequently, these microbial-derived molecules trigger immune activation and metabolic disturbances that contribute to the development and progression of PCOS .

Objective: Research has shown the existence of a close association between the gut microbiota of PCOS patients and the development of insulin resistance, which is a corresponding factor for PCOS, manifesting through short-chain fatty acids, lipopolysaccharides, sex hormones, and the brain–gut axis. Compared with healthy people, the diversity in the gut microbiota of PCOS patients shows a reduction with changes in composition, damaging the intestinal mucosal barrier .

Conclusion: Kefir has a wide spectrum of important health benefits, including physiological, prophylactic and therapeutic properties. These effects are a result of a wide variety of bioactive compounds produced during the fermentation process and the highly diverse microbiota, which act either independently or synergistically to influence these health benefits . Probiotics can improve intestinal barrier function leading to the reduction of intestinal permeability. The absorption of lower amounts of Lipopolysaccharide (LPS) may diminish the low-grade chronic inflammatory process characteristic of diabetes. Moreover, lower LPS may restore the function of insulin receptors leading to a better control of blood glucose, thus kefir might be used in the prevention of diabetes; however, more studies are needed to demonstrate such effects .

Keywords: polycystic ovary syndrome; kefir; gut microbiota; insulin resistance; inflammation; probiotics

Introduction

Polycystic Ovarian Syndrome (PCOS) is a complex endocrine disorder affecting women of reproductive age, characterized by such clinical manifestations as menstrual irregularities, hyperandrogenism, and polycystic ovaries ⁽¹⁾.

Insulin resistance in PCOS Insulin resistance is a central pathogenic feature of polycystic ovary syndrome and characterized by a reduced biological response to insulin in peripheral tissues, particularly skeletal muscle, adipose tissue and the liver. The underlying mechanisms involve post-receptor defects in insulin signaling pathways, leading to impaired glucose uptake despite normal or elevated insulin concentrations ⁽²⁾. To compensate for this decreased insulin sensitivity, pancreatic β -cells increase insulin secretion, resulting in hyperinsulinemia. Elevated insulin levels further exacerbate PCOS by stimulating ovarian theca cells to produce excess androgens and suppressing hepatic synthesis of sex hormone-binding globulin (SHBG), thereby increasing circulating free androgen levels ⁽²⁾.

Gut Dysbiosis and PCOS Pathogenesis Alterations in gut microbial composition play a pivotal role in the pathogenesis of polycystic ovary syndrome (PCOS). Women with PCOS exhibit reduced microbial diversity and an imbalance between beneficial and pathogenic bacterial species, a condition known as gut dysbiosis ⁽³⁾.

This dysbiotic state disrupts intestinal barrier integrity, leading to increased gut permeability “leaky gut”, which facilitates the translocation of microbial products such as lipopolysaccharides into the systemic circulation. Consequently, these microbial-derived molecules trigger immune activation and metabolic disturbances that contribute to the development and progression of PCOS ⁽³⁾.

Kefir is a fermented dairy product that has its origin in the Caucasus, Tibetan or Mongolian mountains, where before 2000 years BC the grains were already being traditionally passed from generation to generation among the Caucasus tribes, being considered a source of family wealth. The name kefir originates from the Slavic Keif, meaning ‘well-being’ living well’, due to the overall sense of health and well-being generated in those who consume it ⁽⁴⁾.

Kefir differs from other fermented products because it is produced from kefir grains that comprise a specific and complex mixture of lactic acid-and acetic acid-producing bacteria, and lactose-fermenting and non-fermenting yeast, which live in a symbiotic association ⁽⁵⁾.

The microorganisms present in kefir possess probiotic potential. Numerous bacterial species isolated from kefir demonstrate high resistance to the low pH and bile salts in the gastrointestinal tract, and are able to adhere to the intestinal mucus ⁽⁶⁾.

Additionally, the microbiota present in kefir can produce antagonistic substances, such as organic acids and bacteriocins that interfere with the adherence of pathogenic bacteria in the intestinal mucosa, potentially contributing to the improvement of gut health ⁽⁷⁾.

Insulin Resistance, Inflammation, Oxidative Stress, and Gut Dysbiosis in PCOS

Insulin resistance in PCOS Insulin resistance is a central pathogenic feature of polycystic ovary syndrome and characterized by a reduced biological response to insulin in peripheral tissues, particularly skeletal muscle, adipose tissue and the liver. The underlying mechanisms involve post-receptor defects in insulin signaling pathways, leading to impaired glucose uptake despite normal or elevated insulin concentrations ⁽²⁾. To compensate for this decreased insulin sensitivity, pancreatic β -cells increase insulin secretion, resulting in hyperinsulinemia. Elevated insulin levels further exacerbate PCOS by stimulating ovarian theca cells to produce excess androgens and suppressing hepatic synthesis of sex hormone-binding globulin (SHBG), thereby increasing circulating free androgen levels ⁽²⁾.

This interaction between insulin resistance, hyperinsulinemia and hyperandrogenism creates a self-perpetuating cycle that leads to follicular arrest, anovulation and the characteristic metabolic disturbances of PCOS ⁽²⁾.

Emerging evidence suggests that oxidative stress interacts closely with chronic inflammation and hyperandrogenism as increased ROS can activate inflammatory pathways and impair mitochondrial function within ovarian granulosa cells, resulting in abnormal folliculo-genesis and ovulatory dysfunction. Moreover, oxidative stress leads to metabolic disturbance by exacerbating insulin resistance and disrupting cellular energy metabolism. Consequently, targeting oxidative stress has been a promising strategy for improving both reproductive and metabolic outcomes in patients with PCOS ⁽⁸⁾. Neuroendocrine dysfunction is also a fundamental component in pathogenesis of PCOS and characterized by dysregulation of the hypothalamic–pituitary–ovarian (HPO) axis. Women with PCOS commonly exhibit an increased frequency of gonadotropin-releasing hormone (GnRH) pulses, which preferentially stimulates luteinizing hormone (LH) secretion over (FSH) leading to elevation in the LH/FSH ratio that promotes excessive androgen production by ovarian theca cells, leading to hyperandrogenism, impaired follicular maturation and anovulation. These neuro-endocrine abnormalities establish a self-perpetuating cycle leading to reproductive and metabolic disturbances in PCOS ⁽⁹⁾.

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This dysbiotic state disrupts intestinal barrier integrity, leading to increased gut permeability “leaky gut”, which facilitates the translocation of microbial products such as lipopolysaccharides into the systemic circulation. Consequently, these microbial-derived molecules trigger immune activation and metabolic disturbances that contribute to the development and progression of PCOS ⁽³⁾.

Increased intestinal permeability promotes the entry of endotoxins into circulation, resulting in chronic low-grade systemic inflammation. Elevated inflammatory cytokines interfere with insulin signaling pathways and contribute to the development of insulin resistance, a hallmark feature of PCOS. Insulin resistance subsequently induces compensatory hyperinsulinemia, which exacerbates ovarian dysfunction and contributes to both reproductive and metabolic abnormalities observed in affected women ⁽¹⁰⁾.

The relationship between gut dysbiosis and hyperandrogenism appears to be bidirectional. Elevated androgen levels can alter the composition of the gut microbiota, while microbial dysbiosis may enhance androgen production through inflammatory and metabolic pathways. Hyper-insulinemia resulting from insulin resistance stimulates ovarian theca cells to increase androgen synthesis, thereby aggravating hyperandrogenism.

This hormonal imbalance contributes to menstrual irregularities, anovulation, and other characteristic manifestations of PCOS, establishing a vicious cycle between gut dysbiosis, insulin resistance, and androgen excess ⁽¹¹⁾.

Emerging evidence indicates that gut dysbiosis may also influence neuro-psychological manifestations of PCOS through the gut–brain axis.

Altered microbial metabolites, inflammatory mediators and neurotransmitter signaling can affect central nervous system function, increasing susceptibility to anxiety, depression, and mood disorders commonly observed in women with PCOS ⁽¹²⁾.

Chronic systemic inflammation and metabolic dysfunction further amplify these effects, suggesting that gut microbiota alterations contribute not only to metabolic and reproductive abnormalities but also the psychological burden in PCOS patients ⁽¹²⁾.

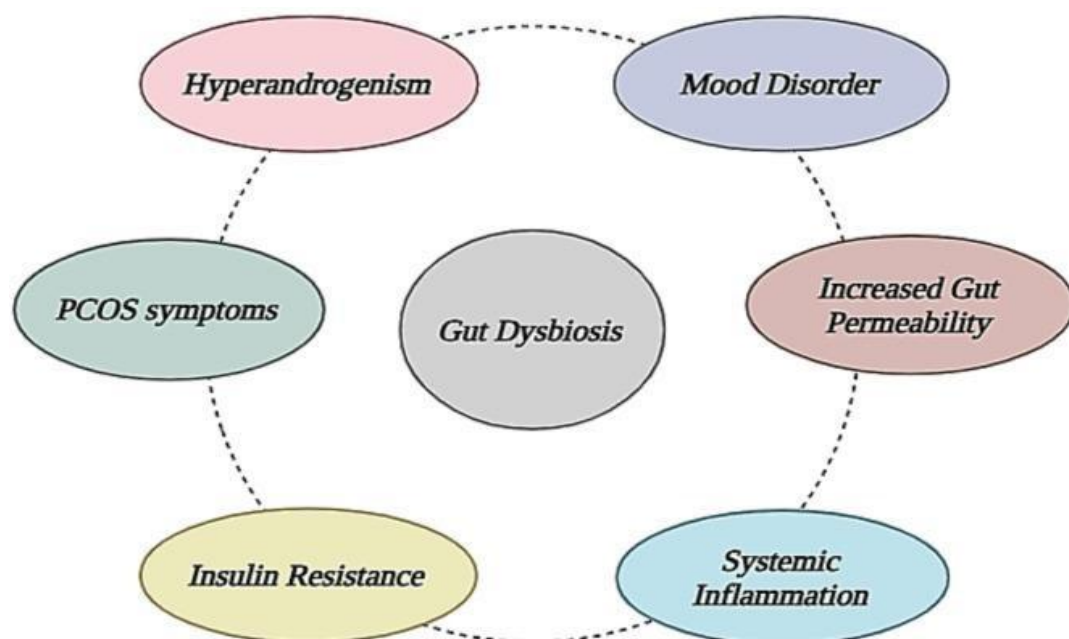


Fig. 1. Illustrates the effects of gut dysbiosis in the development of PCOS. ⁽¹³⁾.

Nutritional Management and the Microbiome

Life style and dietary modifications that include a balanced diet and exercise are the cornerstone of the initial treatment of PCOS before pharmacological intervention ⁽¹⁴⁾.

Low-Glycemic-Index(GI)Diet

which includes foods that cause a slow, gradual rise in blood sugar levels ⁽¹⁵⁾ that helps to improve insulin sensitivity. Further, stable insulin levels help to reduce excess androgen (testosterone)production and help to control symptoms like acne, hirsutism, and irregular menstrual cycles ⁽¹⁶⁾.

Additionally, low-GI foods, like whole grains (oats, quinoa, barley), legumes (beans, lentils), fruits (berries, apples, pears), and vegetables (leafy greens, broccoli, cauliflower), are rich in anti-inflammatory compounds. Findings show that dietary intervention(via a low-calorie, low-glycemic diet) increase suric acid andGPx3 (glutathione peroxidase) activity, further reducing inflammation and oxidative stress ⁽¹⁷⁾.

In recent meta-analysis findings, low-GI diets reduce HOMA-IR, fasting insulin, total cholesterol, LDL cholesterol, triglycerides, waist circumference, and total testosterone levels compared to HGI diets

In women with PCOS ⁽¹⁸⁾.

Microbiome Rich Diet

Research has shown the existence of a close association between the gut microbiota of PCOS patients and the development of insulin resistance, which is a corresponding factor for PCOS, manifesting through short-chain fatty acids, lipopolysaccharides, sex hormones, and the brain–gut axis. Compared with healthy people, the diversity in the gut microbiota of PCOS patients shows a reduction with changes in composition, damaging the intestinal mucosal barrier ⁽¹⁹⁾.

A microbiome-rich diet is rich in fermented foods, whole grains, fruits, seeds, and fiber. It can also be supplied via probiotic or symbiotic supplements, the meta-analysis of 8 RCTs showed that probiotic/symbiotic treatment can effectively improve hormonal, glucose homeostasis, and inflammatory outcomes in PCOS patients ⁽²⁰⁾.

Kefir and Its Microbial Composition

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Kefir has raised interest in the scientific community due to it suggested beneficial properties, including improved digestion and tolerance to lactose, antibacterial effect, hypocholesterolaemic effect, control of plasma glucose, antihypertensive effect, anti-inflammatory effect, antioxidant activity, anti-carcinogenic activity and immune modulatory benefits.

Characteristics of Kefir Grains and Kefiran

Kefir grains have a similar shape to the cauliflower. They are elastic, irregular, gelatinous, with an ivory or white colour, and variable size, from 0.3 to 3.5 cm in diameter (Fig. 3).



Fig. 3. Appearance of kefir grain ⁽²¹⁾.

In general, kefir grain consists of 4.4 % fat, 12.1 % ash, 45.7 % mucopolysaccharide, 34.3 % total protein (27 % insoluble, 1.6 % soluble and 5.6 % free amino acids), vitamins B and K, tryptophan, Calcium, Phosphorus and Magnesium ⁽²²⁾.

Kefiran is the major exopolysaccharide present in kefir grains and is composed primarily of approximately equal proportions of glucose and galactose that supports the symbiotic association between bacteria and yeasts within the kefir grain, contributing to its characteristic texture and stability ⁽²³⁾.

In addition to its structural role, kefir exhibits important physicochemical properties, including water solubility, viscosity, and resistance to gastrointestinal degradation, which may contribute to its biological activities and potential health benefits. The synthesis of kefir is mainly associated with specific lactic acid bacteria present in kefir grains, particularly species of the genus *Lactobacillus* ⁽²³⁾.

In kefir grains, the peripheral portion is composed almost exclusively of bacteria, predominantly *Bacillus*, whereas the inner portion of the grain contains yeasts, and the interface of the inner and outer portions has a mixed composition, where bacteria with long polysaccharide filaments, yeasts and fungi are found (Yilmaz et al. , 2025).

Proper storage techniques are critical to sustain the viability and metabolic activity of the complex microbial community within kefir grains. Short-term storage at refrigeration temperatures 4°C maintains their active state for a limited duration of 8 to 10 days.

To achieve long-term preservation, methods such as lyophilization or drying at room temperature for 36 to 48 hours are deployed, extending their stable shelf life to 12 to 18 months. Alternative dehydration techniques include vacuum drying or conventional thermal drying at 33°C. Despite these various options, experimental

observations demonstrate that freezing the grains at -20°C serves as the most effective method for preserving their functional integrity over extended periods. Under optimized storage conditions, kefir grains can remain stable for multiple years without a significant loss in activity ⁽²¹⁾.

Preparation of Kefir Milk

Preparation of kefir milk

The traditional preparation of milk kefir is a straightforward fermentation process that utilizes live kefir grains with a specific ratio, grains is inoculated into fresh milk inside a clean, glass container, where milk is highly preferred to achieve a desirable, thick consistency. Once the grains and milk are combined, the container is covered with a breathable material to allow the live culture to breathe while preventing external contamination then left to undergo static fermentation at room temperature or refrigerator ⁽²³⁾.

Nowadays, microorganisms isolated from kefir grains or starter cultures containing freeze-dried lactic acid bacteria (LAB) and kefir yeasts are being used in kefir production, but the composition of the final fermented milk produced has a lower number and variety of microorganisms than the fermented milk produced from kefir grains ⁽²⁴⁾.

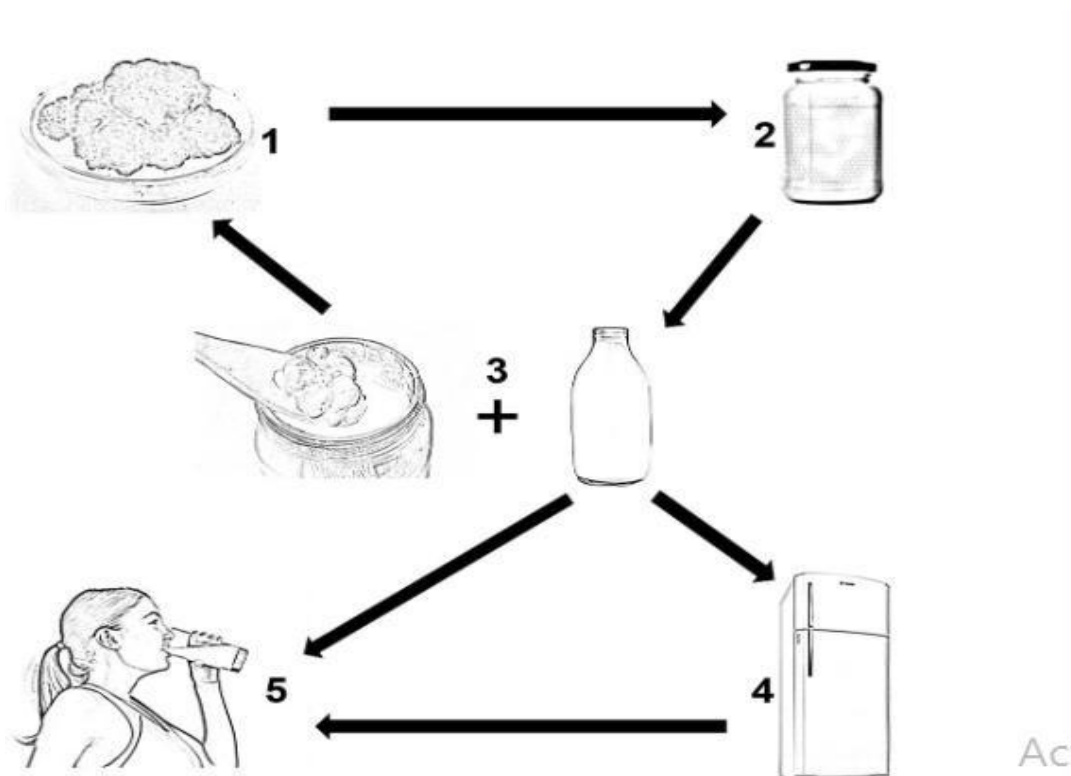


Fig. 4. Domestic production of kefir ⁽²¹⁾.

Steps of preparing traditional kefir

- (1) Separation of kefir grains.
- (2) Addition of milk to the kefir grains in a half-open container at room temperature to ferment for 24h.
- (3) Filtration and separation of kefir grains. Possible addition of the kefir grains to fresh Milk to start a new fermentation. The kefir is adequate for consumption.
- (4) The kefir can be refrigerated (4°C).
- (5) The kefir is safe and ready to drink.

Nutritional Composition of Kefir

Nutritional composition of kefir

The nutritional composition of kefir varies widely and is influenced by milk composition, the origin and composition of the grains used, the time/temperature of fermentation and storage conditions. However, the nutritional composition of kefir is still not well described in the literature.

Regarding the chemical composition, moisture is the predominant constituent (~ 90%), followed by sugars (~ 6%), fat (~ 3%) protein (~ 3%) and ash (~ 0.7 %) ⁽²⁵⁾.

During fermentation, proteins become easily digestible due to the action of acid coagulation and proteolysis. Kefir shows a similar profile of amino acids to the milk used in the fermentation ⁽²⁶⁾.

The levels of ammonia, serine, lysine, alanine, threonine, tryptophan, valine, lysine, methionine, phenyl alanine and isoleucine are higher in kefir compared with unfermented milk. The essential amino acid contents in kefir are in descending order: Lysine (376 mg/g); Isoleucine (262mg/100g); Phenylalanine(231 mg/100)⁽²⁷⁾.

The lactose from milk is degraded to acid during the fermentation process, which causes pH reduction. Approximately 30% of milk lactose is hydrolysed by the β -galactosidase enzyme, turning lactose into glucose and galactose. Furthermore, bacteria present in kefir convert glucose into lactic acid, so kefir is a good option for lactose intolerant individuals ⁽²¹⁾.

The lipid content (monoacyl glycerols, diacyl glycerols and TAG, NEFA and steroids) in kefir can vary depending on the type of milk used in the fermentation. In the fermented milk, the presence of NEFA contributes to the improvement of digestibility ⁽²¹⁾.

Kefir contains a rich vitamin composition, when it is ready for consumption. The vitamin content depends on the quality of the milk used, microorganisms present in the kefir grains, and the way of preparation. Kefir presents vitamins B1, B2, B5, C, A and K, and carotene in its composition. The concentration of pyridoxine, vitamin B12, folic acid, biotin, thiamine and riboflavin increase during the fermentation process ⁽²¹⁾.

Among the minerals, kefir is a good source of Magnesium, Calcium and Phosphorus. Additionally, minerals such as Zinc, Copper, Manganese, iron, Cobalt and Molybdenum are found in milk kefir.

Lactic acid, CO₂ and ethanol are the main products that originate from the lactose fermentation process. Kefir also contains formic, propionic and succinic acids, aldehydes, traces of acetone and isoamyl alcohol, and a variety of folates. The pH of kefir varies between 4.2 and 4.6, ethanol content between 0.2 and 0.5%(v/v), lactic acid between 0.8 and 1.0 %(w/v) and CO₂ between 0.08 and 0.2 (v/v) ⁽²¹⁾.

Biogenic amines such as putrescine, spermidine and tyramine are also found in kefir samples as a consequence of the LAB activity. The high levels of biogenic amines are related to the depreciation of the sensorial properties of fermented milk, and are considered to be an important indicator of quality and acceptability.

The high concentration of bioactive amines in fermented products, especially putrescine, cadaverine, agmatine and N-methylputrescine, as well as monoamines such as penicillamine and histamine are positively correlated with inharmonious bitter taste ⁽²⁸⁾.

Total biogenic amines contents in kefir samples between 4.2 and 35.2 mg/l, with tyramine being the most abundant bioactive amine. These values, however, are far below the recommended limits. ⁽²⁹⁾.

Finally, several compounds that are generated during fermentation exert a direct influence on the aroma and taste of kefir, such as lactic acid, acetic acid, pyruvic acid, hippuric acid, propionic acid, butyric acid, diacetyl and acetaldehyde ⁽³⁰⁾.

Health Effects of Kefir

Health effects of kefir

Kefir has a wide spectrum of important health benefits, including physiological, prophylactic and therapeutic properties. These effects are a result of a wide variety of bioactive compounds produced during the fermentation process and the highly diverse microbiota, which act either independently or synergistically to influence these health benefits ⁽²¹⁾.

Antimicrobial properties of kefir

Studies of the early twentieth century observed that the positive effect on life expectancy of regular consumption of yogurt containing lactic acid-producing microorganisms was due to the existing competition between Lactic acid bacteria and harmful pathogens. Since then, antifungal and antibacterial activities of probiotics like kefir have been extensively studied ⁽²¹⁾.

Antibacterial properties of kefir are related to a combination of several factors, including competition for available nutrients and the inherent action of organic acids, H₂O₂, acetaldehyde, CO₂ and bacteriocins produced during the fermentation process. These substances also exhibit some effects similar to those of nutraceuticals, preventing gastrointestinal disorders and vaginal infections ⁽³⁰⁾.

Kefir exerts bactericidal effects on Gram-negative bacteria; however, it is more potent against Gram-positive bacteria. This antagonistic action has been observed against bacteria, such as *Salmonella*, *Shigella*, *Proteus vulgaris*, *Staphylococcus*, *Helicobacter pylori*, *Escherichia coli*, *Enterobacter aerogenes*, *Bacillus subtilis*, *Micrococcus luteus*, *Listeria monocytogenes*, *Streptococcus pyogenes* and also against the yeast *Candida albican* ⁽²¹⁾.

In an in vitro study that tested the antimicrobial activity of kefir grains and kefir suspension against several species of bacteria and fungi and observed higher inhibitory action against *Streptococcus faecalis* and *Fusarium graminearum*. The concentration of kefir from 7 to 10% (w/w) was able to completely inhibit the sporulation of *Aspergillus flavus*, and consequently the production of aflatoxin B₁, which demonstrates the antifungal properties of kefir against filamentous fungi ⁽³¹⁾.

The organic acids produced during fermentation of kefir can change the molecule aflatoxin B₁, by converting it into less toxic forms such as aflatoxicol, aflatoxin B and B_{2a}. In this context, kefir appears as a safe alternative for food preservation, providing protection against poisoning from aflatoxin B₁. Additionally, kefir was able to increase the population of LAB and reduce the levels of Enterobacteriaceae and *Clostridium* in the intestinal mucosa of mice ⁽²¹⁾.

Control of plasma glucose by kefir

The regular consumption of probiotics has the ability to improve blood sugar levels. This effect has been attributed mainly to the probiotic ability to positively modulate the composition of the intestinal microbiota and hence reduce intestinal permeability, oxidative stress and inflammation ⁽³²⁾.

Probiotics can improve intestinal barrier function leading to the reduction of intestinal permeability. The absorption of lower amounts of Lipopolysaccharide (LPS) may diminish the low-grade chronic inflammatory process characteristic of diabetes. Moreover, lower LPS may restore the function of insulin receptors leading to a better control of blood glucose, thus kefir might be used in the prevention of diabetes; however, more studies are needed to demonstrate such effects ⁽²¹⁾.

3-Hypocholesteremic effect of kefir

This effect is driven by multiple synchronized biological pathways within the gastrointestinal tract. A primary mechanism involves the enzymatic activity of bile salt hydrolase (BSH), which is produced by the diverse probiotic bacteria and yeasts, such as *Kluyveromyces marxianus*, residing in kefir that catalyzes the deconjugation of bile acids in the intestine, forming free bile salts that are easily excreted rather than reabsorbed via entero hepatic circulation ⁽²¹⁾.

To compensate for this loss and synthesize new bile acids, the liver must harvest cholesterol directly from the bloodstream, thereby up regulating low-density lipoprotein (LDL) receptor expression and reducing serum LDL cholesterol levels. Additionally, lactic acid bacteria (LAB) present in kefir have been shown to physically bind and assimilate exogenous cholesterol within their cell walls, preventing its absorption across the intestinal mucosa ⁽²¹⁾.

4-Anti-inflammatory properties of kefir

Kefir consumption exerts a potent anti-inflammatory effect primarily by modulating the systemic production of signaling molecules called cytokines. The diverse probiotic strains and bioactive compounds within kefir actively suppress the nuclear factor kappa B (NF- κ B) signaling pathway, which is the main trigger for chronic inflammation. Regular intake of kefir has been shown to significantly down regulate the expression of major pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF- α), interleukin-1beta (IL-1 β), and interleukin-6 (IL-6). At the same time, it upregulates the secretion of anti-inflammatory cytokines like interleukin-10 (IL-10), effectively restoring immune system balance and alleviating systemic inflammatory responses ⁽³³⁾.

The anti-inflammatory properties of kefir are also closely linked to its ability to improve gut health and repair the intestinal mucosal barrier. The combination of lactic acid bacteria (LAB), yeasts, and the exopolysaccharide "kefiran" enhances the integrity of tight junction proteins in the gut, preventing harmful bacterial toxins (such as lipopolysaccharides or LPS) from leaking into the bloodstream—a condition known as metabolic endotoxemia. By maintaining a healthy gut microbiome and strengthening mucosal immunity, kefir effectively reduces localized intestinal inflammation as well as secondary systemic inflammation, making it a valuable dietary intervention for inflammatory bowel diseases (IBD) and related metabolic disorders ⁽³⁴⁾.

5-Anti oxidative activity of kefir

Kefir exhibits a potent antioxidant effect primarily driven by the production of bioactive peptides during the fermentation process. When lactic acid bacteria (LAB) and yeasts break down milk proteins (especially caseins) via microbial proteases, they release short-chain peptides that possess strong radical-scavenging abilities. These generated peptides, such as specific proline-containing sequences, can effectively donate hydrogen or electrons to stabilize reactive oxygen species (ROS), thereby inhibiting lipid peroxidation and preventing subsequent cellular damage ⁽³⁵⁾.

kefir actively modulates the body's internal defenses by regulating key endogenous antioxidant enzymes. In vivo and animal model studies indicate that dietary supplementation with kefir components can reverse age-associated oxidative stress in vital organs like the brain and liver. It achieves this by significantly reducing harmful biomarkers of oxidative damage, such as malondialdehyde (MDA), while simultaneously boosting the activities of essential protective enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px), which restores systemic redox homeostasis ⁽³⁶⁾.

The magnitude of kefir's antioxidant efficacy is highly dependent on the microbial diversity of the kefir grains and the fermentation substrate used. During fermentation, the cooperative metabolism between bacteria and yeasts enhances the overall total antioxidant capacity (TAC), providing robust multi-functional protection against chronic disorders related to oxidative stress ⁽³⁴⁾.

Conclusion

Kefir has a wide spectrum of important health benefits, including physiological, prophylactic and therapeutic properties. These effects are a result of a wide variety of bioactive compounds produced during the fermentation process and the highly diverse microbiota, which act either independently or synergistically to influence these health benefits ⁽²¹⁾.

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Based on all this, although the positive effects of kefir on health in different diseases have been shown so far, Therefore, this study was conducted to evaluate the effects of kefir consumption on health outcome in patients with PCOS.

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