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Review Article

Properties and benefits of kefir -A review

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Abstract

Kefir is becoming increasingly popular as a result of new research into its health benefits. It is a fermented milk drink which has its origin in the Caucasus Mountains of Russia. Kefir is prepared by inoculating milk with kefir grains which are a combination of bacteria and yeasts in a symbiotic matrix. The common microorganisms present are non-pathogenic bacteria, especially *Lactobacillus* sp. and yeasts. Kefir has a long history of health benefits in Eastern European countries. It is believed that kefir has therapeutic effects, thus it is important to study the various properties contained in, and exhibited by it. This review includes a critical revision of the antimicrobial, anti-carcinogenic, probiotic and prebiotic properties of kefir. Other health benefits, like reducing cholesterol and improving lactose tolerance are also discussed.

Keywords: kefir, antimicrobial, anti-carcinogenic, cholesterol, probiotic

1. Introduction

In recent years fermented milk and milk products have had a strong influence on health. They are considered to be beneficial with therapeutic effects and various other properties. Researchers have identified yet another fermented milk drink, kefir. The word 'kefir' is derived from the Turkish word 'keif' which means 'good feeling' (Kaufmann, 1997). The drink originated in the Caucasus Mountains of Russia, which are between the Black and the Caspian Seas. Kefir is produced by the fermentation of lactic acid and alcohol by mesophilic bacteria and yeasts, respectively (Ahmed *et al*., 2013).

Kefir can also be prepared by inoculating milk with kefir grains which are a combination of bacteria and yeasts in a symbiotic matrix. Most microorganisms present in kefir are non-pathogenic bacteria, especially *Lactobacillus* sp. and yeasts. Kefir is enriched with vitamins, amino acids, carbon dioxide, acetoin, alcohol and essential oils which have been shown to have health benefits. Recently, the antibacterial, immunologic and antitumor effects of kefir were studied on human beings (Lin and Change, 2000).

Various properties are exhibited by kefir. Some of the main ones discussed here are antimicrobial, anti-carcinogenic, probiotic and prebiotic. Kefir has long been considered good for health (Liu *et al*., 2006 a). Guven *et al*. (2003) proposed an alternative suggestion as to how kefir may protect tissues. They found that mice exposed to carbon tetrachloride (a hepatotoxin to induce oxidative damage) and given kefir by gavage showed decreased levels of liver and kidney malondialdehyde, indicating that kefir was acting as an antioxidant.

Their data also indicated that kefir was more effective than vitamin E (which is well known to have antioxidative properties) in combating oxidative damage. Many studies have shown evidence to warrant the use of probiotic foods like kefir in the treatment of gastrointestinal disturbances (Reid *et al*., 2003). One example is diarrhea, which can be caused by a variety of conditions. Probiotics help in preventing diarrhea and in reducing its duration; they also alleviate conditions such as infant's diarrhea, irritable bowel

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syndrome, colitis, Crohn's disease, gastroenteritis, and traveler's diarrhea (Heyman, 2000). The consumption of kefir has shown good results in mitigating the symptoms of chronic constipation (Maeda *et al*., 2004).

This review outlines the properties and benefits of kefir and its effects regarding health remedies.

2. Origin of Kefir

Kefir is a popular traditional Middle Eastern beverage. Consumption of kefir leads to a 'good-feeling' (Chaitow and Trenev, 2002). It originated in the Caucasus Mountains in the former Soviet Union, in Central Asia and has been consumed for thousands of years (Libudzisz and Piatkiewicz, 1990). Kefir grains were first described by the tribes in the Northern Caucasian mountain region of Russia (Seydim, 2001).

Historically kefir grains were considered as gifts from Allah among the Muslim peoples of the Caucasian Mountains. They were passed down from generation to generation among the tribes of Caucasus and considered a source of family wealth. Traditional authentic kefir can be prepared by culturing fresh or pasteurized milk with kefir grains in homes all over the world (Roberts *et al*., 2000).

2.1 Codex alimentarius description of kefir

According to the Codex Standard for Fermented Milks CODEX STAN 243-2003, kefir contains the following: milk protein minimum (2.7%w/w), milk fat (<10m/m), titratable acidity expressed as percentage of lactic acid minimum (0.6% m/m), ethanol (not stated), sum of specific microorganisms constituting the starter culture minimum (10^7 cfu/g, in total) and yeast minimum (10^4 cfu/g).

3. Kefir Production

There are several methods for kefir production and commonly both traditional and industrial processes are used. Food scientists are currently studying modern techniques to produce kefir with the same characteristics as those found in traditional kefir. Kefir can be made from any type of milk, cow, goat, sheep, coconut, rice or soy. There are many choices for milk; pasteurized, unpasteurized, whole fat, low fat, skim and no fat (Semih, and Cagindi, 2003). Similarly, several processes have been developed to produce a kefir-like beverage in which no grains are used. In Russia, a mother culture is prepared by carrying out traditional kefir fermentation and sieving the grains. About 1 to 3% of this mother culture is added to pasteurized milk and incubated at 19 to 28ºC for 24 hours. (Farnworth and Mainville, 2003).

4. Functional Properties of Kefir

The functional properties of kefir are discussed in detail below and a schematic diagram is presented in Figure 1.

4.1 Antimicrobial properties

Kefir has an antibacterial effect against many pathogenic organisms due to the inherent formation of organic acids, hydrogen peroxide, acetaldehyde, carbon dioxide, and bacteriocins. For example, 3.5 kDa bacteriocin was identified from *Lactobacillus plantarum* ST8KF in kefir (Powell *et al*., 2007). Besides this, hydrogen peroxide is another metabolite produced by some bacteria as an antimicrobial compound. Yuksekdag *et al*. (2004a) showed that all 21 isolates of lactic acid bacteria from Turkish kefir produced hydrogen peroxide (0.04-0.19 µg/ml). In a later paper, they reported that 11 out of 21 strains of kefir *Lactococci* produced hydrogen peroxide (Yuksekdag *et al*., 2004). All *Lactococci* strains were effective in inhibiting the growth of *Streptococcus aureus,* but were less effective against *Escherichia coli* NRLL B-704 and *Pseudomonas aeruginosa.*

Furthermore, Santos *et al*. (2003) stated that the bacteriocin named lacticin 3147, which was produced by *Lactococcus lactis* strain DPC3147 isolated from kefir grains, had antimicrobial activity against *Escherichia Coli*, *Listeria monocytogenes*, *Salmonella typhimurium, S. enteritidis, S. flexneri*, and *Yersinia enterocolitica*. The molecular structure of lactin 3147 is shown in Figure 2. In addition, Ahmed *et al*. (2011) reported that kefir suspension, kefiran (a proposed molecular structure of kefiran is shown in Figure 3), and kefir grains showed antibacterial activity against some unicellular bacterial species and new antifungal activity against filamentous fungal species.

Moreover, many scientists (Diniz *et al.,* 2003; Kwon *et al.,* 2003; Rodrigues *et al.,* 2005; Schneedorf and Anfiteatro, 2004) stated that kefir and its exopolysaccharide, kefiran, had antimicrobial activity. Both were reported to exhibit significant antibiotic activity against Gram-positive and Gram-negative bacteria as well as yeast, *Candida albicans*. Similarly,

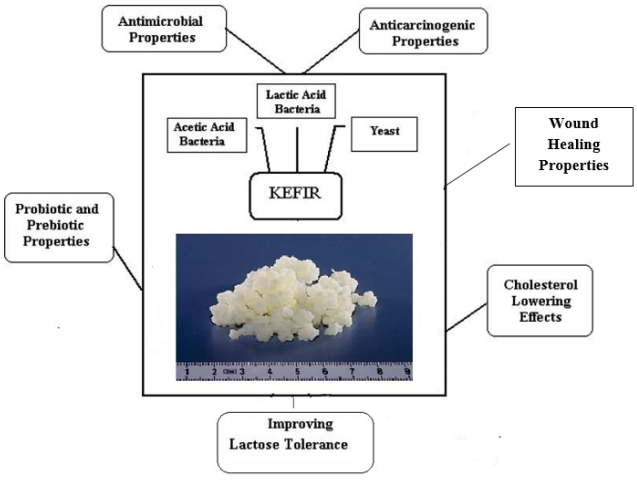

Figure 1. Schematic diagram of the functional properties of kefir (Zeynep, *et al*., 2011; Kniesel, 2005)

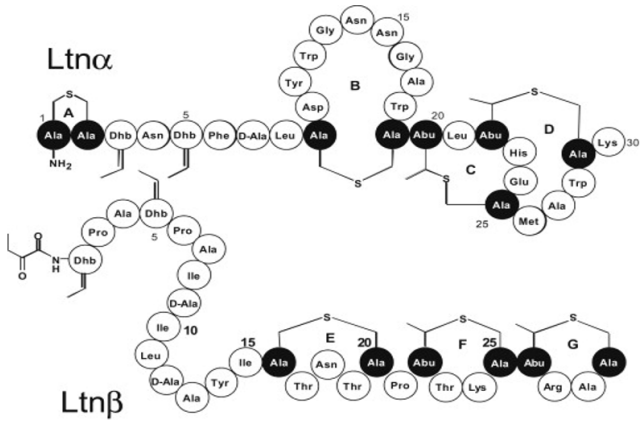

Figure 2. Molecular structure of Lacticin 3147. (Srinivas *et al.,* 2010)

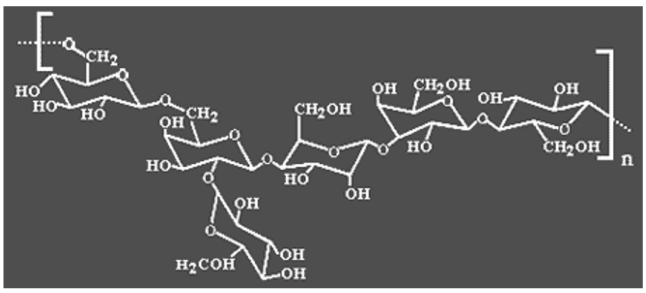

Figure 3. Chair form diagram of the proposed molecular structure of kefiran (Anfiteatro. 2013)

Medrano *et al*. (2008) reported that kefiran, an exopolysaccharide produced from kefir grains, protected against *Bacillus cereus* B 10502 damage to Caco-2 cells when introduced at a concentration range from 300 to 1000 mg/l. Their study also revealed that kefiran was capable of protecting cultured enterocytes significantly from the activity of *B. cereus* B10502 supernatants.

Data presented by Beyza *et al*. (2007) also suggested that kefir may be a good antimicrobial agent in food technology for food safety. More research related to this subject has still to be performed, in order to put the antimicrobial activity of kefir into practice for food technology.

4.2 Anti-carcinogenic properties and inhibition of tumor growth

According to the Merriam Webster medical dictionary, the definition of a anti-carcinogenic is 'tending to inhibit or prevent the activity of a carcinogen or the development of carcinoma'. Tumors are classified as carcinomas or sarcomas. Sarcoma tumors are derived from supportive or connective tissues such as bone, fat, and cartilage (Kuby, 1994). In addition, Liu *et al*. (2002) studied the effects of freeze-dried kefir, produced from soy milk and cows' milk with kefir grains, on the growth of tumors in mice. Mice were injected with Sarcoma 180 cells for one week before the start of the feeding stage of the experiment. Tumor growth (volume) was estimated for up to 30 days. Both soy milk kefir (70.9%) and cows' milk kefir (64.8%) significantly inhibited tumor growth, compared with mice in the positive control group.

In a study on induced breast cancer in mice, De Moreno *et al*. (2006) reported that mice receiving two days cyclical feeding with both kefir and a cell-free fraction of kefir over 27 days had a reduced tumor growth and increase in the IgA(+) cells. They also suggested that the IgA(+) cells might be able to bind the toxic metabolites produced during tumor development and indicate the importance of non-microbial components released during milk fermentation.

In addition, kefir extracts have been shown to suppress the growth of breast cancer cells *in vitro*. Some antitumorigenic abilities of kefir have been associated with the exopolysaccharide kefiran. Kefiran was shown to inhibit Ehrlich carcinoma and Sarcoma 180 in a mouse study, where it was proposed that the polysaccharide stimulated the host immune system via T-cell activity, rather than acting against the cancerous cells directly.

Furthermore, several studies have shown that kefir extracts and kefir bacterial isolates have the potential to reduce the risk or arrest the development of cancerous growths *in vitro* or in animal models (Rattray and Connell, 2011).

In 2008, Topuz and his team conducted the first study on the effect of oral kefir consumption on serum pro-inflammatory cytokines and on CT induced oral mucositis in humans with cancer. Their results showed that oral kefir consumption did not have any effect on the serum pro-inflammatory cytokines or a protective effect on mucositis due to 5-FU (a drug used in the treatment of cancer) based CT in humans. The team also suggested that further studies were needed to understand the effects of oral kefir consumption on the human immune system.

4.3 Cholesterol lowering effect

The evidence that kefir consumption reduces serum cholesterol is limited. Some research results have indicated a decrease in total serum cholesterol and phospholipids, in rats fed with a high cholesterol diet supplemented with kefir. Other biomarkers, such as high density lipoprotein (HDL) and serum triglycerides were unaffected by kefir consumption (Rattray and Connell, 2011). However, Liu *et al*. (2006) reported that milk kefir and soy milk kefir lowered the serum triacylglycerol and total cholesterol concentrations in hamsters. They also showed that the increase in the cholesterol-lowering effect of soy milk kefir, compared with soy milk, might be attributable to hypocholesterolaemic compounds other than genistein present in the kefir but absent from the soy milk.

Furthermore, some scientists (Brashears *et al*., 1998; Tamai Y *et al*., 1996) suggested that reduced serum choles-

terol concentration induced by kefir could be attributed to the deconjugation of bile acids by *Lactobacillus* spp. A study by Reynier and his team (1981) revealed that deconjugation of bile acids reduced serum cholesterol levels by increasing the formation of new bile acids needed to replace those that have escaped the enterohepatic circulation. They also showed that higher cholesterol metabolism lowered the serum cholesterol level.

In 2006, Begley *et al*., studied the mechanisms behind the deconjugation of bile acids by bile salt hydrolase. A detailed drawing is given in Figure 4a. In their study, they showed that the key enzyme bile salt hydrolase from *Lactobacillus* spp was responsible for the conversion of conjugated bile acids to unconjugated bile acids. They also showed that the deconjugation of bile salts could lead to a reduction in serum cholesterol, either by increasing the demand for cholesterol "de novo" synthesis of bile acids, to replace those lost in feces, or by reducing cholesterol solubility and thereby absorption of cholesterol through the intestinal lumen.

In addition, Cenesiz *et al*. (2008) found that there was a decrease in serum cholesterol levels of all kefir-treated chickens in a dose-dependent manner. They also concluded that a decrease in cholesterol levels could be associated with both a reduction in cholesterol biosynthesis in the liver and an increase in degradation of bile acids by *Lactobacillus* species. Similarly, Sanders (2000) suggested that the inhibition of 3HMG-Co A, which is an intermediate of mevalonate, during the synthesis of cholesterol from acetyl-Co A by fermented milk products, was the reason for the reduced level of cholesterol in the serum. A detailed drawing is given in Figure 5.

Moreover Yoon *et al*. (1999) reported that cholesterol assimilation was strain -dependent and *L. acidophilus* CU673 isolated from kefir displayed the highest cholesterol assimilation activity with a 68.8% reduction. According to the report by Kalavathy *et al.* (2009), cholesterol removal from the growth medium by the *Lactobacillus* strains may be strain dependent. However, further studies are required to determine the mechanisms involved in the removal of cholesterol by these *Lactobacillus* strains *in vitro*.

In addition, Maeda *et al*. (2005) found that kefiran-fed rats had a serum cholesterol lowering effect in 2 rat models which were loaded with cholesterol and given orotic acid.

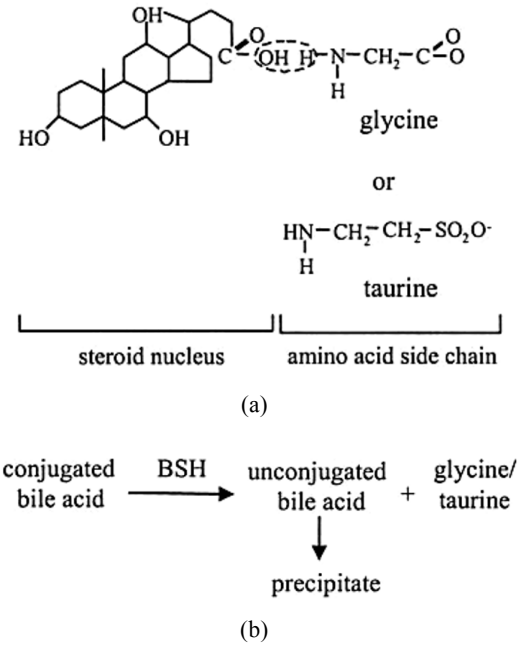

Figure 4. (a) Chemical structure of bile acids. Bile acids are conjugated with either glycine or taurine prior to secretion. (Begley *et al.,* 2006). (b) Reaction catalyzed by bile salt hydrolase enzymes. BSHs cleave the peptide linkage of bile acids, which results in the removal of the amino acid group from the steroid core. The resulting unconjugated bile acids precipitate at low pH. (Begley *et al.,* 2006).

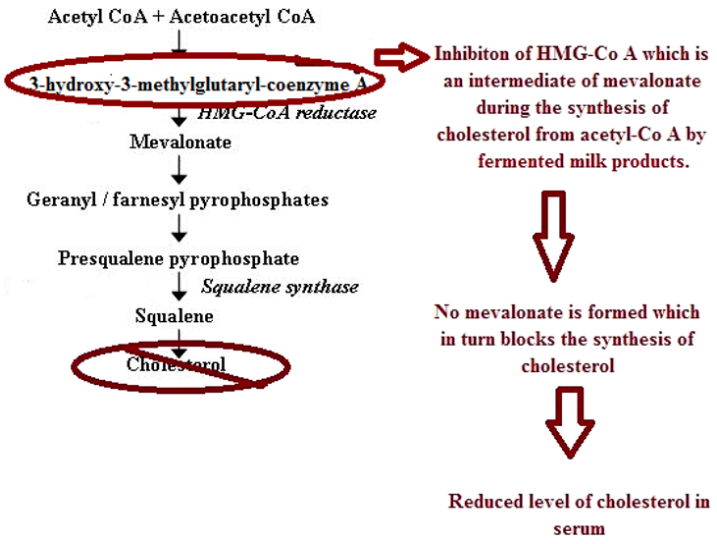

Figure 5. Cholesterol biosynthesis pathway (modified) (Bate *et al*., 2007; Sanders. 2000)

Kefiran accelerated sterol excretion and protected hepatic injuries (glutamate oxaloacetate transaminase [GOT], glutamic pyruvic transaminase [GPT]) in both rat models. The mechanisms for this are not well understood.

4.4 Improving lactose tolerance

Lactose maldigestion is the inability to completely digest lactose, the major carbohydrate in virtually all mammalian milks. Lactose maldigestion affects 75% of adults in the world and occurs most often as the result of a genetically programmed decrease in intestinal lactose activity after the age of 3 to 5 years (Sahi, 1994; Swaggerty *et al.,* 2002).

Hertzler and Clancy (2003) demonstrated that a commercial kefir produced from a starter culture containing six bacteria (but not *L. acidophilus*) and one yeast, was equally as effective as yoghurt in reducing breath hydrogen in adult lactose maldigestors. It has also been shown that fermented milk products have a shorter transit time than milk, which may further improve lactose digestion (Vesa *et al*., 1996; Labayen *et al*., 2001). Furthermore, Rattray and Connell (2011) found that kefir with a diverse microbial population invariably has some degree of β-galactosidase activity, that converts lactose into glucose and galactose, which can then be easily digested.

In addition, Steven *et al.* (2003) reported that although it seems plausible that kefir might improve lactose digestion in a manner similar to yogurt, there is a lack of research to support such a claim. Kefir contains different starter culture microorganisms from yogurt and the bile acid sensitivity, galactosidase activity, or lactose transport of these organisms may be different. This was the first result found, which demonstrated that plain kefir improved lactose digestion just as well as plain yogurt.

4.5 Wound healing properties

As kefir is a probiotic mixture of a diverse spectrum of bacteria and yeasts Witthuhn *et al.,* (*2005*), it can stimulate innate immune responses in defense against pathogens (Koutinas *et al.,* 2007; Atalan *et al*., 2003). Chena *et al*. (2008) and Kyoung *et al*. (2007) stated that the anti-inflammatory properties of polysaccharide present in kefir extract may also be influential in the process of wound healing. The lactic acid, acetic acid, polysaccharides and other chemicals present in kefir were important factors for wound healing properties observed in a study by Hassan *et al*. (2012).

In 2005, Kamila *et al*. conducted a study on rats, treating them with a simple kefir formulation made from dried grains. The results showed better wound healing properties compared with those treated with the clostebol–neomycin emulsion. Similarly, In 2005 Rodrigues and his team proved that rats treated with 70 % kefir gel made with kefiran, showed a faster reduction of the infected-induced wound compared with clostebol–neomycin emulsion. A study by Hassan *et al*. (2012) also showed that kefir had better wound-healing properties than conventional silver sulfadiazine treatment with regard to thermal injuries.

5. Probiotic and Prebiotic Properties

Kefir is a complex microbial system that has not only been found to be nutritionally beneficial, but has also been proven to inhibit a number of food-borne pathogens and spoilage microorganisms (Paucean and Carmen, 2008). Many probiotic products have been formulated that contain small numbers of different bacteria. The microbiological and chemical compositions of kefir indicate that it is a much more complex probiotic. Since yeasts and bacteria present in kefir grains have undergone a long association, the resultant microbial population exhibits many similar characteristics, making isolation and identification of individual species difficult. Many of these microorganisms are only now being identified by using advanced molecular biological techniques (Edward, 2006).

Kefir can be considered an amazing example of co-evolution of a microbial consortium. It has acquired a strong resistance against several microorganisms, as well as improving the natural immunity of mammals from early times. It is reasonable to think of the consortium as a potential naturally-occurring drug, able to decrease a large variety of illness afflictions (Jose, 2012). In 2003, Santos and his team reported that several strains of *Lactobacillus* spp. isolated from kefir in various countries have good adhesion to Caco-2 cells. These strains were resistant to low pH and bile acid and had antimicrobial activity against common enteropathogenic bacteria, which are popular criteria required by probiotic bacteria.

In addition, prebiotics are considered non-digestible but fermentable oligosaccharides, involving health promotion for the host (Barbosa *et al*., 2011).These compounds are known to provide improvements in nutritional status, in addition to health benefits such as protection against carcinogenesis, mutagenesis, prevention of injuries caused by free radicals, control of intestinal flora, and gastrointestinal resistance. Importantly kefir is able to produce peptide and sugar prebiotics, e.g., lactacin, bacteriocins, and kefiran (Schneedorf and Anfiteatro, 2004).

6. Benefits of Kefir for Pregnant and Nursing Women

According to the National Kefir Association, pregnant and nursing women can safety consume kefir. This promotes the absorption of nutrients, increases immunity, helps the body adjust to hormonal changes and prevents infections such as yeast overgrowth (Sandra, 2013). Also, the consumption of kefir by pregnant women can prevent the overgrowth of a bacterium called group B Beta Streptococcus. Beta streptococcus is a harmful bacterium which can cause infections such as sepsis, pneumonia, and meningitis (Sandra, 2013).

7. Conclusions

Scientific studies indicate kefir to be a complex probiotic, which is a combination of bacteria and yeasts. Kefir has certainly been shown to contain various functional properties such as antimicrobial, anti-carcinogenic, probiotic and others. It provides healthful benefits in the cholesterol lowering effects and improved lactose tolerance in humans. This fermented milk appears to have a great potential and this should inspire researchers to carry out further studies on kefir in order to analyze the hidden therapeutic and functional properties which have not been revealed to date.

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