© 2017 IJSRST | Volume 3 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

A Review on the Role of Fermented Foods as Health Promoters

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ABSTRACT

Food is a word that lures the taste buds. But when fermentation comes in between then it is not the case for taste only as the health gets involved too. Different microbial cultures are used in fermenting process that renders different tastes, different textures and even different characteristics to fermented foods. Fermented foods have been in use since prehistoric times. They are easily produced and commercially available as well. They not only have nutritional effect but have health promoting characteristics as well. Kefir, Soy, Cheese, Kimchi are some of the most notable fermented foods. Their consumption can modulate the immune system, prevent allergies, detoxify body and can battle pathogenic microorganism. They have been reported to lower cancers risk and lower the damaging cholesterol level. High cholesterol content is found to be associated with coronary diseases. Chemical medications to heal wounds leave certain side effects such as hyperpigmentation. Fermented foods can be used as an alternative in healing the wounds. Their role in increasing proper brain functioning (cognitive functions) is also significant. More research and analysis is required to understand the fermented foods well.

Keywords : Immunomodulation, Kefir, Kimchi, Kombucha, LDL, Detoxification

I. INTRODUCTION

Fervere, a Latin term apparently is a small word but is of immense importance and has revolutionized the life. It means to 'boil'. When Yeast was observed growing over malt extract as its substrate, boiling like appearance was noted. This boiling appearance was CO_2 bubbles produced as a result of now called term FERMENTATION (Patra *et al.*, 2016). It was in actual anaerobic breakdown of malt via yeast that resulted in bubbling appearance. This process was then adopted for alcohol production (Kim *et al*., 2016; Patra *et al*., 2016). Time passed and people started using this process for bread and dough making leading to the establishment of fermented foods. That is food that is either obtained by a microbe or has been preserved using them. The science that lies behind it is the Fermentation and thus dates back to prehistoric times. Many advances have been made in it with the time man has been evolving (Marco *et al*., 2017).

We have reached that point where fermented foods are considered to be a staple diet. From breakfast to dinner, each meal of ours consists of at least anything that is fermented (McGovern *et al*., 2004). Fermented foods have a mystery of their own that makes them complex and sometimes difficult to understand. They consist of different microbes and metabolites, each of which plays a role in the well-being of mankind (Stanton *et al.*, 2005; Mackowiak, 2013).

Not only fermentation enhances the nutritional value but is also used to preserve food. It is considered as the biological mean of preserving food. Because constituents of these foods includes ethanol, oils, organic acids and bacteriocins. All these are antimicrobial in nature. In this way spoilage of food is prevented as they will not microbes to colonize or grow. Foods texture and taste is preserved this way and there is also an increase in shelf life of food (Chilton *et al.*, 2015). Each fermented food has characteristics of its own that is in some way beneficial to humans. In certain cases fermentation of foods becomes a necessity. Such as Olives have phenolic compounds that give them a bitter taste (Marco *et al.*, 2017). To avoid this bitterness microbial way is used to get rid of these phenolic compounds. Similarly for preparing bread, good leavened dough is required. The leavening of dough is in

fact the *Saccharomyces cerevisiae* undergoing fermentation and producing CO_2 that raises the dough (Patra *et al.*, 2016).

Cardiovascular diseases are prevalent in today's world. These diseases are related to cholesterol deposition. Using different fermented foods the cholesterol level can be lowered and heart diseases can be avoided (Marco *et al.*, 2017). Similarly, The Gastrointestinal health can be protected using fermented foods. These foods have anti-allergic, anti-microbial and anti-carcinogenic effect as well. The brain can work properly and the memory can be enhanced by adding these foods in yours menu list. The beneficial effects of these foods are enormous and these foods are easi.ly prepared and are economical (Ebner *et al.*, 2014).

The aim of this review is to unveil all those ravishing aspects that can promote the health and established their status as health promoters (Patra *et al.*, 2016).

II. Notable Fermented Foods

Certain notable foods of fermentation that have been reported to promote the human health and have long since been used are described below whereas their primary sources of fermentative organisms are tabulated in Table I.

A. **Kimchi**

Kimchi is the most popular side dish in Korean meals. It is fermented food and is obtained by fermentation of salt seasoned vegetables especially cabbage. *Lb. brevis, B. subtilis, Lb. parabrevis B. mycoides, Lb. sakei, B. pseudomycoides, Lc. carnosum, Lc. lactis, Lb. pentosus, Lb. curvatus* and *Lb. plantarum* are among many of the microorganisms present in Kimchi**.** In old times Kimchi was stored for a long time by keeping them in jars that were stored underground and used when needed. Kimchi of different varieties having different fermented vegetables is available commercially (Patra *et al.*, 2016).

B. **Kefir**

Milk is not cultured from grains except a unique fermented food termed as Kefir. These grains are white in color and gel like in texture. Casein that is milk protein in these grains is coupled with yeast or bacteria. Sugars are also there. Big expanded sheets are used to grow these grains. These grains are added to the milk. On addition the grains exert their fermentation characteristics. The milk is freed of grains using strainers and is ready to use in next batch (Sjogren *et al.*, 2009).

C. **Soy**

Soy bean excessively grown for nutritional content is called *Glycine max*. It is a legume and has been reported to diminish the risks for heart diseases. Different types of food that are made with soy fermentation are Miso, Yogurt and Tempeh. Miso is rich in salt and has paste like consistency and is a fermented product (Romond *et al.*, 1998). Yogurt is a fermented soymilk product. Bacterial cultures ferment it. It is used in ice creams and sour creams. Indonesian cuisine consists of many fermented products .One of which is Tempeh that is soybean mixed with a mold and rice and then cultured for about a day. It is chewable and can be grilled too (Wang *et al*., 2004).

D. **Cheese**

A rich source of protein and fats is Cheese. It is a milk product and can be made from milks of sheep, cow, goat or buffalo. Casein gets coagulated in milk leading to the formation of cheese. The bacterial culture eats up all the sugar content in the milk and a byproduct that is lactic acid is produced. Such a process is termed as aging. Cheese exists in different textures and flavors depending upon types of culture used in its fermentation (Camfield *et al*., 2011).

E. **Kombucha**

It is a fermented tea and locally termed as Mushroom tea too. It consists of bacterial and yeast colony that undergoes fermentation in the presence of sugar thus giving its name of fermented tea. Vitamin B and vinegar are also so present in kombucha. It has been reported to play role in immunomodulation, anti-carcinogenic activity, wound healing and modulation of gut system (Jarrell *et al*., 2000; Rolle & Satin, 2002).

TABLE I

TABLE ABOUT DIFFERENT FERMENTED FOODS AND SOURCES OF FERMENTATIVE ORGANISMS FOR THESE FERMENTED FOODS

Food	Sources of organisms	Organisms
Yogurt	Starter culture	*St. thermophilus, L. delbrueckii*
Cheese, sour cream	Starter culture, back slopping	*Lc. lactis, Lu. mesenteroides*
Wine	Spontaneous, starter culture	*Sa. cerevisiae, O. oeni*
Beer	Back slopping, starter culture	*Sa. cerevisiae (L. brevis)*
Bread	Starter culture	*Sa. cerevisiae*
Sourdough bread	Back slopping	*L. sanfranciscensis, C. humilis*
Sauerkraut or kimchi	Spontaneous	*Lu. mesenteroides, L. plantarum, L. brevis*
Olives	Spontaneous	*L. plantarum*
Soy sauce, miso	Starter culture, spontaneous	*A. soyae, Z. rouxii, T. halophilus*
Tempeh	Starter culture, back slopping	*R. oligosporus*
Natto	Starter culture, back slopping	*B. subtilis*

I. HEALTH PROMOTING CHARACTERISTICS

These foods have been studied and worked on to understand their health promoting nature. The ways these foods better the human health are:

A. Modulation of Immune system (Immunomodulation)

The immune system is the host defense system of a living being. Microbes have been found to be associated with the modulation of immune system but recent advances have also established a link between fermented foods and the immune system independent of microbes (Brandtzaeg, 2002; Rhee *et al.*, 2004; Smits *et al*., 2005). Animal trials revealed a significant increase in IL-2 IL-4, IL-6, IL-10, IgA and IgG levels, all of which are responsible for Th2 response, in organisms fed with fermented products (Pulendran *et al*., 2001). Fermented products have the ability to effect systemic and immune responses and thus are a basic constituent of infant formula. They can induce Th1 responses or regulatory T-cells thus being a reason for immune balance and tolerance development in infants (Qi *et al*., 2003; Kapsenberg, 2003).

B. Gastrointestinal Health

Gastrointestinal tract health is of extreme importance. A little imbalance in GIT health can result in a lot of damage. It is the home for a large number of microbes that makes it even more vulnerable. Anything that is eaten will be processed in the gastrointestinal tract whether its food or antibiotics. The accumulation of harmful material such as toxins in the body has a negative impact on the body. The vital organs such as kidney, heart and liver are the first to get effected. The damage to these organs is indicated by the symptoms such as skin disorders, joints inflammation, backache and headache etc. Unhealthy eating or immense use of antibiotics can disturb the microbiota of GIT. This disturbance of GIT will then provide site and conditions for bad (pathogenic) bacteria to grow that are not the normal residents of GIT. The colonization of such bad bacteria will lead to decrease in good bacteria. The human body then suffers diseases such as diarrhea, severe headaches, bloating, and inflammation (Parvez *et al.*, 2006). Thus the consumption of fermented foods will provide metabolites and substances required for the growth of good bacteria in GIT and these foods will also provide normal resident microbes to GIT. The good bacteria will grow and restore their number. The body will then start to perform normally. Regular ingestion of fermented foods will keep on adding new good bacteria to resident microflora of GIT, thus keeping GIT protected and healthy (Kim *et al.*, 2016).

Normally when foods are fermented, they do not carry any microbes in themselves. But exceptions are always

there. Foods such as Kimchi, fermented sausage, Cheese, Kefir, Yogurt that are widely used on daily basis ,consists of live microbial cells that is 106-109 cells/g. A large number of these cells easily passes through all barriers of GIT and get colonized. According to an estimate if fermented foods are taken regularly the amount of bacteria can reach up to 10^3 fold (Di Cagno *et al.*, 2013; Kim *et al.*, 2016).

C. **Nutrient absorption**

Digestive fire is a term generally used to express the body ability to absorb nutrients. This nutrient absorption is due to activity of certain enzymes. These are the products of the gastrointestinal microflora. Fermented foods have the ability to increase the absorption of nutrients inside the gastrointestinal tract (Calder *et al*., 2006). The enzymes present in these foods help to better the digestion process. For those of you who tend to eat a lot of cooked or packaged foods void of enzymes, adding them to your diet can greatly enhance nutritional uptake (Granier *et al.*, 2013; West, 2014).

These enzymes rich foods have developed a strong market. They are laxative in nature as well. Thus people with problems of constipation or difficult bowel movement can have these foods to have a health and a better bowel movement (Ewaschuk *et al.*, 2008). Research has suggested that if cooked beans are consumed they help in digestion. It makes the peristaltic movement better. The absorption of nutrients such as amino acids and proteins is increased if beans are consumed. Similarly another traditional Indonesian food Tempeh is easy to produce. It can be fermented with 24 hours to 36 hours. Its consumption will also increase nutrient absorption (Calder *et al.*, 2006; Depeint *et al*., 2008). Each and everything is consumed within a certain range. That is overeating or excess of something can be deleterious as well so is the case with fermented foods. There are certain foods that must be taken in small quantity (Romond *et al.*, 1998). Stomach disorders are mostly related to consumption of foods that are overeaten. Thus this way will lead to nutrient loss instead of nutrient absorption (Depeint *et al*., 2008).

D. **Detoxification**

The human body can become home for different toxins. These toxins might be a part of the diet that the human intakes. The accumulation of these toxin leads to a stage termed as toxification. It is highly essential to get rid of such toxins out of body otherwise they could be damaging. The process of their removal is termed as Detoxification (Endrizzi *et al.*, 2009; Swain *et al.*, 2014). A compound known as Glucuronic acid binds with toxic material and removes or eliminates it from the body. This compound is abundantly present in a fermented food, Kombucha (Akira & Hemmi, 2003). It has been used in Chinese traditions for treating different ailments. Kombucha can thus be used to detoxify body of harmful toxins. Not only Glucuronic acid, but additional components such as epigallocatechin, Acetic acids, Vitamin C and Lactic acid also contribute in the detoxifying ability of Kombucha (Swain *et al*., 2014).

E. **Lowering Cholesterol level**

Presence of high levels of cholesterol in humans is one of the leading causes of cardiovascular diseases (Fig.1). To reduce high levels of cholesterol it's important to take account of cholesterol metabolism (Beena & Prasad, 1997; Sibel *et al*., 1997; Zhuang *et al*., 2012). For this purpose, fermented milks are being used for so long. Animal trials have shown a significant decrease in serum cholesterol when Kefir milk was consumed. The *Lactobacillus plantarum* MA2 of Kefir is responsible for hypocholesterolemic activity (Benjamin *et al*., 2016). Similarly when yoghurt consisting of *Lactobacillus reuteri* was consumed, the levels of LDL-cholesterol and total cholesterol were decreased, too (Vujici *et al*., 1992; Liu *et al.*, 2012). The consumption of Kimchi (Korean cuisine-fermented food) can also reduce triglycerides, serum cholesterol, cardiac risk factor ,the atherogenic index, LDL-cholesterol levels in adipose tissues and liver (Patra *et al*.,2016).

Moreover there are also certain other factors that are related to Cholesterol and in turn are related to cardiac arrest. This fermented food, Kimchi, if taken has the ability to control all these factors as well and exerts positive impact on them. Those notorious factors that could be one of the causes for cardiovascular disease are hypotension, hypertension, metabolic syndrome and the amount of fasting glucose (Park *et al*., 2014).

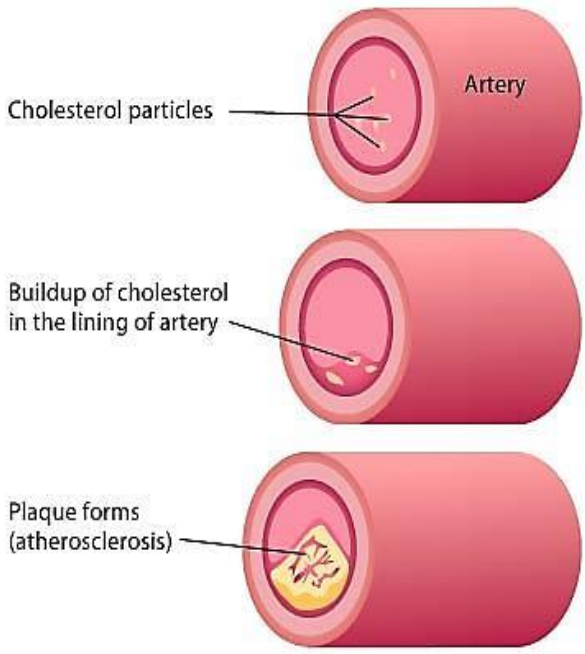

Figure 1 : Cholesterol deposition leading to atherosclerosis

F. **Anti-Allergens**

Allergy, a hypersensitive reaction of the immune system to something in the environment, creates havoc sometimes (Isolauri *et al*., 2002; Sjogren *et al*., 2009). Even certain foods are able to initiate or accelerate the immune system. This acceleration leads to abnormal behavior of body termed as Food Allergy. Food allergies are not rare. Every third person is found to be effected by them. Their rate of incidence is increasing day by day. Certain foods reported to be troublesome for adults are peanuts, fish, different tree nuts especially walnuts and shell fish. However food reported to be trouble causing in children are peanuts, tree nuts, milk, soy, eggs and wheat. The consumption of such food initiates an allergic response that could be converted to a severe form known as anaphylaxis. The death rate due to anaphylactic shock is evident (Sjogren *et al*., 2009). The food allergies can be detected by symptoms such as Irritation or inflammation in mouth, gastrointestinal tract disorders, Eczema, Difficulty in breathing and swallowing and Low blood pressure (Isolauri *et al*., 2002).

These allergies are being treated by chemical means. The use of chemical medication is making microorganisms resistant. Thus Instead of consuming chemical medication, the allergies can also be treated using fermented foods. Research has indicated that the entrance or permeation of antigens of food responsible for allergy can be prevented by consuming Kefir, the fermented milk. As a result there would not be any allergic response generation. Different foods were tested to check their ability to suppress the responses by IgE and IgG. Soy milk and Kefir proved to have the best results if used. They also altered the gut microflora. This ability of them proves that they can resist the pathogenic microbes and such fermented foods can help prevent allergies (Tamime, 2002). Eating yogurt reduces allergic symptoms by increasing the number of lactic acid bacteria. Consumption of coconut milk, kimchi and soy milk also have anti-allergic properties. Infants with high number of *Lactobacillus* sp. and *Bifidobacterium* sp. in gut have been found to report lower allergic incidences than infants that have fewer amounts of these bacteria (Yazdanbakhsh *et al*., 2002; Wood, 2003).

G. **Anti-carcinogens**

Uncontrolled proliferation of cells that can be localized or spreading is termed as cancer. It is in fact a group or cluster of diseases that all relate to abnormal growth of cell. If remains untreated, it can lead to death. It is being treated using chemotherapy. These drugs being highly strong leaves certain deleterious effects on human body, hair loss, reduction in WBCs, anemia is among one of the major effects. To have least damaging side effects of cancer treatment, fermented foods are being considered (Cevikbas *et al*., 1994). Kimchi a local food of Korea is a fermented cabbage. The products formed as a result of Kimchi fermentation or the constituents of Kimchi have been reported to have anti-carcinogenic properties (Fig.2). They can suppress the carcinogenic enzymes expression. If these foods are taken regularly, they can prevent the risk of occurrence of cancer and if are taken during early stages can help prevent the tolerance against anti-tumor drugs (Kabak & Dobson, 2011; Kwak *et al*., 2014).

A bacterium that is notorious for causing ulcers and cancer is *Helicobacter pylori*. These ulcers and Cancer is GIT related. Antibiotics recommended in such cases mostly fail to eliminate *H.pylori* out of GIT and if get eradicated, it recolonizes as conditions become favorable thus setting stages for diseases like Cancer and Ulceration. However, study of the past indicates the

presence of *H.pylori* but the occurrence of ulcers or Cancer was not so high as compared to today .All this was related to their eating habits (Hamet *et al.*, 2013; Nair *et al.*, 2016). They consumed fermented products (foods) that had antibacterial activity. Such foods daily consumption did not let this bacterium to colonize or to affect them severely. If fermented foods like Yogurt, Kefir, and fermented milk are consumed regularly, we can have a solution to this problem. A large number of fermented foods have been found to have antibacterial activity that's make them anti-carcinogenic agents as well (Kwak *et al*., 2014; Nair *et al*., 2016).

A body if exposed to a radiation can undergo mutations in its cells and ultimately cause cancer. Miso soup is a traditionally consumed fermented food. It is formed by boiling the paste at a temperature lesser than boiling point of water otherwise the nutritional constituents of Miso soup would have been lost (Stanton *et al*., 2005). The consumption of Miso soup chelates the effect of the exposed radiation. This chelating is due to presence of Dipicolinic acid. As a result breast cancer rate can be lowered in the community. Similarly researches are being done to check for the Miso soup anti-carcinogenic activity against prostate cancer (McGovern *et al*., 2004; Stanton *et al.*, 2005).

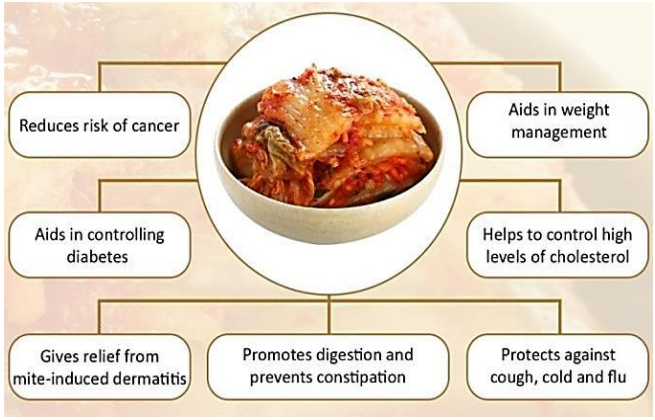

Figure 2: Health benefits of Kimchi

H. Anti-microbial agents

The intensive and repeated use of antibiotics has led to resistance development in both bacteria and fungi. The microbes of today are getting smarter and their smartness is causing harm to humans (Cevikbas *et al*., 1994; Powell *et al*., 2007). Fermented foods such as Kefir (fermented milk) have been reported to have bactericidal activity against a number of notorious pathogenic bacteria such as *Salmonella typhimurium* and most fungal species as stated in Table II. Their bactericidal activity is found to be equivalent to commercially available antibiotics such as azithromycin, ketoconazole, ceftriaxone, ampicillin and amoxicillin, paving their way to be used as antimicrobial agents (Santos *et al.*, 2003; Golowczyc *et al.*, 2008; Benjamin *et al*., 2016).

TABLE II
MICROBIAL SPECIES AGAINST WHICH KEFIRS ANTIMICROBIAL CHARACTERISTIC IS REPORTED

Microbial species	
Bacteria	**Fungi**
Staphylococcus aureus	*Candida albicans*
Pseudomonas aeruginosa	*Yersinia entocolitica*
Salmonella enteritidis	*Aspergillus flavus*
Listeria monocytogenes	*Aspergillus niger*
Salmonella enterica	*Rhizopus nigricans*
Enterococcus faecalis	*Candida stellatoidea*
Escherichia coli	*Rhodotorula glutinis*
Shigella flexneri	*Penicillium glaucum*

I. Wound healing

A puncture or cut in skin is termed as wound. It often heals own its own but the process of healing can be slow too. This slow healing or insufficiency to heal can be damaging in certain cases. Yogurt, a fermented food, is the source of Zinc that is highly essential for healing of wounds. It boosts the process of tissues formation by playing a helping hand in the divisions of cells. It also prevents infections of the wounds. Yogurt also consists of Potassium, Vitamins, Iron and Fat that are the promoters for recovery (Swain *et al*., 2014).

When a skin is burnt, it becomes vulnerable to attack by microorganisms. The normal flora of skin itself is an opportunistic pathogen. The colonization of microbes at the site of burn leads to infection. Burns are measured or categorized as degrees**.** *Psuedomonas aeruginosa* present in air has the ability to infect the site of burns of

third degree (Huseini *et al*., 2012). Silver sulfadize is normally applied to reduce such burns by *P. aeruginosa*. But recent researches have provide evidence found the decrease in burns wound size when gels made from a fermented food such as Kefir, were applied over it. It also reduced the healing time and made the wounds cleaner (Rhee *et al*., 2004; Demir *et al.,* 2006). Kefirs ability to kill bacteria and fungi or to retard their growth was found to be the reason for cleaner wounds in certain studies. The factor that is involved in the process of wound healing is the ability of the fermented foods to modulate or regulate the immune system and to aid in the selection of new cells that have much to do with the healing process (Atalan *et al*., 2003; Huseini *et al*., 2012).

J. **Improvements in Brain and cognitive functions**

Dairy products have been used since prehistoric times within many civilizations as one of the practice for better health (Camfield *et al.,* 2011; Calder *et al.,* 2016). This aspect of fermented dairy products consumption has been supported through different researches and studies relating improvements in brain and cognitive functions (Fig.3). An increase in memory in elderly people was reported due to consumption of such food products. Moreover experiments on animal models have shown that fermented products such as cheese have neuroprotective effects (Kim *et al.,* 2016). The cheese not only increased the production of neurotropic factor and chemokine by hippocampus but also suppressed the death of neurons. The cheese also increased the anti-inflammatory activity (Ozawa *et al.,* 2013; Jung *et al.,* 2014).

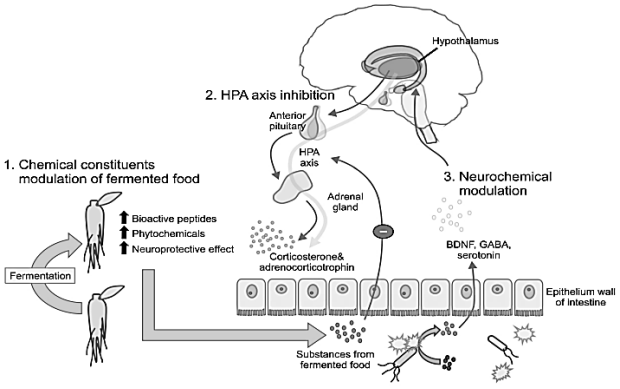

Figure 3: The way fermented food regulates brains function

III. CONCLUSION

The interest in the use of microorganisms and foods for promoting human health has been increased and their relation with human health is being more exploited to understand and avail more and more benefits. Fermented foods not only provide nutritional content but the foods natural content is preserved in it as it is Thus the use of fermented foods such kefir, milk, yogurt, cheese, kimchi and many others can help promote human health. Use of such foods will eliminate the risk of antimicrobial resistance, heart diseases, toxification and allergies to a great extent. They will provide a better brain, a better memory, a better GI health and a body less affected by carcinogens or radiations. Further research and experimentation is required to extract the most benefits for health out of these fermented foods.

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