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***Review Article***

# BACTERIAL NUTRACEUTICALS - A BENEFICIAL HEALTH SUPPLEMENT

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## ABSTRACT
The food product that reportedly provides health and medical benefits, including the prevention and treatment of disease is nutraceutical. Bacteria such as lactic acid bacteria (LAB) are used all over the world in nutraceuticals. Other examples are the yoghurt bacterium *Streptococcus thermophilus* and the cheese and butter (milk) bacterium *Lactococcus lactis*. This property offers the possibility to fortify fermented dairy products with folate by natural means, i.e. without the addition of food supplements. Some lactic acid bacteria, such as *Lactococcus lactis*, are able to produce and excrete riboflavin into the surrounding medium. Certain bacterial strains also function as probiotics defined as "Live microorganisms which when administered in adequate amounts confer a health benefit on the host". Bacterial neutraceuticals are "good" bacteria consumed into the gut, which help to maintain immune system activity, and in turn help the body react more quickly to new infections.

## INTRODUCTION
Nutraceutical, a portmanteau of the words “nutrition” and “pharmaceutical”, is a food or food product that reportedly provides health and medical benefits, including the prevention and treatment of disease. The term nutraceutical was originally defined by Dr. Stephen L. De Felice, founder and chairman of the Foundation of Innovation Medicine (FIM), Crawford, New Jersey.

### *Types of Bacteria*
Bacteria such as lactic acid bacteria (LAB) are used all over the world in a large variety of industrial food fermentations (Chelule *et al.,* 2010). Their contribution in these fermentation processes primarily consists of the formation of lactic acid from the available carbon source resulting in a rapid acidification of the food raw-material, which is a critical parameter in the preservation of these products. However, besides their lactic acid forming capacity, LAB also have the ability to contribute to other product characteristics like flavour, texture and nutrition.

LABS are also applied at an industrial scale in the fermentation of other food-raw materials like meat and vegetables. Production of neutraceuticals viz. sugars such as mannitol, sorbitol, and tagatose, as a result of metabolic engineering of lactic acid bacteria, is also carried out.

Some of the starter bacteria used in dairy fermentation execute *de novo* biosynthesis of folates and secrete a surplus of these compounds into the growth medium (Kleerebezem *et al.,* 2002). Examples are the yoghurt bacterium *Streptococcus thermophilus* and the cheese and butter (milk) bacterium *Lactococcus lactis*. This property offers the possibility to fortify fermented dairy products with folate by natural means, i.e. without the addition of food supplements. Some lactic acid bacteria, such as *Lactococcus lactis*, are able to produce and excrete riboflavin into the surrounding medium (Roland *et al.,* 2002).

Based on this idea, fermented products could serve as valuable source of this vitamin for the human diet. In recent studies on *Lactobacillus reuteri*, some interesting observations were made on the production of a neutraceutical which is a cobalamin-like substance,especially in the presence of glycerol which is converted in this organisms to propanediol (and to hydroxypropionaldehyde, reuterin) through a cobalamin dependent enzymatic step. Heterofermentative lactic acid bacteria such as *Leuconostoc mesenteroides* are known for their ability to produce mannitol in the fermentation of fructose (Soetaert *et al.,* 1995). These bacteria convert part of the fructose for energy generation via the usual heterofermentative pathway while the other part of fructose is reduced directly to mannitol. In this way,

high yield of mannitol is found, especially when fructose is supplied with glucose. Also, considerable sorbitol production, another important neutraceutical has been observed in *Lactobacillus plantarum* strains. The use of lactic acid bacteria could, very well, be an attractive alternative in the production of tagatose (Rooijen *et al.,* 1991).

***Composition of Bacterial Nutraceuticals***

Bacterial Nutraceuticals have been documented physiological benefit on human health. Consumption of nutraceuticals has been claimed to reduce the risk of certain chronic diseases e.g. diabetes, hypertension, immune-regulatory diseases etc.

Generally, the major nutrient constituents in bacterial nutraceuticals are antioxidants, which are known to be efficacious in the treatment and prevention of a wide range of chronic illnesses. Examples are phenolics or more accurately described as polyphenolics such as tocopherols and tocotrienols. Polyphenol antioxidants are generally believed to be instrumental in combating oxidative stress in humans, a process associated with some neurodegenerative diseases and some cardiovascular diseases.

Typically, nutraceutical compositions are formulated in various forms depending on intended application e.g. solutions, colloidal dispersions, oil-in-water or water-in-oil suspensions, creams, gels, lotions, powders, foams, mousses, suppository etc.

The tocotrienol containing powder of US '372 mainly comprises an oil containing tocotrienol, cellulose, lecithin, an emulsifying agent (gelatin, casein sodium, arabic gum or modified starch), and a powdery substance as an oil absorbent.

***In Vitro Culture of Bacteria***

A method for producing any bacterial nutraceutical composition comprising of water soluble antioxidants derived from a mixture of two or more bacterial species, includes the steps of: (i) preparing mixed consortia of known bacterial species; (ii) centrifuging the bacterial composition into solid pellets; (iii) powdering the pellets and introducing into capsules, or making other forms as powder, emulsion or addition into any food product for consumption.

*In vitro* growth and storage -First, the microbiology laboratory, where the original bacterial strains are kept, prepares the inoculation material, which is a small quantity of bacteria of a single (pure) strain. Then, the inoculation material is multiplying and growing either in fermenters (liquid) or on a surface (solid) under defined and monitored conditions. Grown cells of pure bacterial culture are harvested, eventually blended with other bacterial species, and, finally, formulated (preserved) for subsequent transportation and storage. These formed bacterial nutraceuticals are sold in liquid, frozen or freeze-dried formats.

***Health Benefits***

Certain bacterial strains also function as probiotics defined as "Live microorganisms which when administered in adequate amounts confer a health benefit on the host". Lactic acid bacteria (LAB) and bifidobacteria are the most common types of microbes used as probiotics, alongwith certain bacilli. Probiotics are commonly consumed as part of fermented foods with specially added active live cultures, such as in yogurt, soy yogurt, or as dietary supplements. Probiotics are also delivered in fecal transplants, in which stool from a healthy donor is delivered like a suppository to an infected patient.

Specific health effects are being investigated and documented including alleviation of chronic intestinal inflammatory diseases, prevention and treatment of pathogen-induced diarrhea, urogenital infections, and atopic diseases after consumption of neutraceuticals.

Experiments into the potential health effects of supplemental probiotics include the molecular biology and genomics of *Lactobacillus* in immune function, cancer, and antibiotic-associated diarrhea, travellers' diarrhea, pediatric diarrhea, inflammatory bowel disease and irritable bowel syndrome.

Some bacterial neutraceuticals *viz.,* probiotics possibly treat various forms of gastroenteritis. They might reduce both the duration of illness and the frequency of stools and diarrohaea. The treatment with probiotic formulations including *Lactobacillus rhamnosus* may reduce the risk of antibiotic-associated

diarrhea, improve stool consistency during antibiotic therapy, and enhance the immune response after vaccination.

Neutraceuticals are beneficial to lactose intolerant individuals. Ingestion of certain active bacterial strains may help lactose intolerant individuals tolerate more lactose than they would otherwise have tolerated.

In laboratory investigations, some strains of LAB (*Lactobacillus delbrueckii subsp. bulgaricus*) have demonstrated anti-mutagenic effects thought to be due to their ability to bind with heterocyclic amines, which are carcinogenic substances formed in cooked meat. LAB have evidence for acting against colon cancer in rodents. Some human trials hypothesize that the strains tested may exert anti-carcinogenic effects by decreasing the activity of an enzyme called β-glucuronidase (which can generate carcinogens in the digestive system). Lower rates of colon cancer among higher consumers of neutraceuticals viz. fermented dairy products, bacterial fermented foods.

Animal studies have demonstrated the efficacy of some strains of LAB at being able to lower serum cholesterol levels, presumably by breaking down bile in the gut, thus inhibiting its reabsorption (which enters the blood as cholesterol). The effects of a yogurt with probiotic strains of bacteria on serum cholesterol levels found a minor change in total cholesterol concentration, and a decrease in serum LDL (Low Density Lipoprotein) concentration.

Neutraceuticals have been found to correspond to a possible improvement of LDL (Low Density Lipoprotein) /HDL (High Density Lipoprotein) ratio. The consumption of neutraceuticals like milk fermented with various strains of LAB may result in modest reductions in blood pressure.

Some strains of LAB may affect pathogens by means of competitive inhibition (i.e., by competing for growth) and there is evidence to suggest that they may improve immune function by increasing the number of IgA-producing plasma cells, increasing or improving phagocytosis as well as increasing the proportion of T lymphocytes and Natural Killer cells in human body. Clinical trials have demonstrated that neutraceuticals viz. probiotics may decrease the incidence of respiratory tract infections and dental caries in children. They are also utilised in the treatment of acute diarrhea, and possibly affect rotavirus infections in children and travelers' diarrhea in adults. Bacterial neutraceuticals are "good" bacteria consumed into the gut, which help to maintain immune system activity, and in turn help the body react more quickly to new infections.

Some strains of LAB may affect *Helicobacter pylori* infections (which may cause peptic ulcers) in adults. The bacterial nutraceuticals may prevent reoccurrences of inflammatory bowel disease in adults, as well as improve milk allergies.

In one study, a bacterial commercial strain of *Bifidobacterium infantis* improved some symptoms of irritable bowel syndrome in women (Whorwell *et al.*, 2006). A separate small study showed that a strain of *Lactobacillus plantarum* may also be effective in reducing IBS symptoms. A study focused on *Bifidobacterium animalis* showed a reduction in discomfort and bloating in individuals with constipation-predominant IBS, as well as helping to normalize stool frequency in said individuals.

A 2007 study at University College Cork in Ireland showed that a diet including neutraceutical viz. milk fermented with *Lactobacillus* bacteria prevented *Salmonella* infection in pigs. A 2007 preliminary study at Imperial College London showed that a commercially available probiotic drink containing *Lactobacillus casei DN-114001* and yoghurt bacteria might reduce the incidence of antibiotic-associated diarrhea and *C difficile*-associated diarrhea (Hickson *et al.*, 2007). They worked as life saving bacterial nutraceuticals.

Current research is focusing on the molecular biology and genomics of *Lactobacillus* strains and bifidobacteria. The application of modern whole genome approaches is providing insights into bifidobacterial evolution, so that more types of bacterial nutraceuticals may be developed.

Bacterial food cultures are also used in food production. They carry out fermentation process in foodstuffs. Used by humans since the Neolithic period (around 10 000 years BC) bacterial fermentation helps to preserve perishable foods and to improve their nutritional and organoleptic qualities (relating to

the senses, taste, sight, smell, touch). These forms of nutraceuticals are described for their beneficial use in fermented food products from all over the world.

The scientific rationale of the function of bacteria in fermentation has started to be built following the discoveries of Louis Pasteur in the second half of 19th century. Since then, thanks to extensive scientific studies bacterial Food Cultures, traditionally used in food fermentation are being characterized (taxonomically, physiologically, biochemically and genetically) as nutraceuticals. The utilisation of nutraceuticals allows better understanding and improving of traditional food processing and opens up new fields of applications.

The bacterial nutraceuticals also preserve food through formation of inhibitory metabolites such as organic acid (lactic acid, acetic acid, formic acid, propionic acid), ethanol, bacteriocins, etc., often in combination with decrease of water activity (by drying or use of salt). Besides, they help to improve food safety through inhibition of pathogens or removing of toxic compounds. Moreover, nutraceuticals improve the nutritional value and organoleptic quality of the food.

Bacterial nutraceuticals are basic bacterial starter cultures and probiotics. The Starter cultures have mainly a technological function in the food manufacturing. They are used as food ingredients at one or more stages in the food manufacturing process, which develop the desired metabolic activity during the fermentation or ripening process. They contribute to the one or multiple unique properties of food stuff especially in regard to taste, flavor, colour, texture, safety, preservation, nutritional value, wholesomeness and/or health benefits.

Probiotics have a functional role, which refers to the ability of certain microbes to confer health benefits to the consumers. Generally, the bacteria used as starter culture are not the same used as probiotics. There are however cases when one bacterium can be used both as starter culture and as probiotics. The most important bacteria in food manufacturing are *Lactobacillus* species, belonging to the group of Lactic acid bacteria. Bacterial nutraceuticals are utilised for the aroma, taste and texture of cheeses and fermented milk products like yoghurts, ayran, doogh, skyr or ymer. They contribute to develop the flavor and colour of such fermented products as salami, pepperoni and dried ham. Lactic acid bacteria convert the unstable malic acid that is naturally present in wine into the stable lactic acid. This malolactic fermentation gives the stability that is characteristic of high-quality wines that improve on storage. Lactic acid bacteria are also used in food supplements as probiotics which help to restore the balance in human's intestinal biota. The industrial production of bacterial nutaceuticals is carried out after careful selection process and under strictly controlled conditions.

Bacterial nutraceuticals are also considered as traditional food ingredients and are permitted in the production of foodstuffs all over the world under general food laws. Commercially available bacterial cultures are sold as preparations, which are formulations, consisting of concentrates of one or more bacterial species and/or strains including unavoidable media components carried over from the fermentation and components, which are necessary for their survival, storage, standardization and to facilitate their application in the food production process.

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