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The Benefits of Lactic Acid Bacteria in Yogurt on the Gastrointestinal Function and Health

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Abstract: The nutritional value of yogurt and Lactic Acid-producing Bacteria (LAB) on the gastrointestinal health and function, have been investigated in this study. Both *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (LAB) species, contribute to the formation of yogurt as a result of anaerobic fermentation of lactic acid in the milk. The present study focuses on the effect of yogurt consumption as a basic Mediterranean dietary tradition, improving the health and longevity. Among adults, life expectancy was the highest in the world and the rate of coronary heart disease, cancer and other diet related chronic disease, were among the lowest, in which yogurt is considered the main source of diary products in the Mediterranean diet, incorporated with other healthy foods (fruit, vegetable, brown bread, cereals and olive oil). Numerous studies suggested beneficial therapeutic effect of (LAB) bacteria in the yogurt on the gut health. (LAB) bacteria can protect against enteric infection and inhibit chemically Carcinogens induce tumorization in the gastrointestinal tract. Combination of Probiotics active culture and prebiotics non digestible food ingredient, beneficially affect the host by improving the survival of live microbial dietary supplement through its transit in the gut and by stimulating the activity of colon bacteria, specially *Bifidobacteria* and *Lactobacilli* genera. The benefits of yogurt consumption on the gastrointestinal function mediated through the gut micro flora, bowel transit and the enhancement of gastrointestinal immune responses. Certain disease with gastrointestinal tract such as, lactose intolerance, diarrhea, colon Cancer, inflammatory bowel disease and other bacterial infection were inhibited through high consumption of yogurt as based diary food product.

Key words: Yogurt, lactic acid-producing bacteria, diary food product

INTRODUCTION

The growing popularity of yogurt over the years, has largely been increased due to its perceived health benefits. Yogurt is one of the best-known foods that contain "probiotics" which is a living microorganism, upon ingestion in sufficient amount, exerts beneficial effects on the normal microbial population of the gastrointestinal tract (Bourlioux *et al*., 2003). Different microbial species are considered as probiotics. The major strains *Lactobacillus acidophilus, L. casei.* and various *Bifidobacterium* species , *B. longum, B. bifidum* are the most dominant species in human small and large intestine, that can inhibit the growth of pathogenic organisms, through production of organic acids and bacteriocins (Mazza, 1998).

Among the most important food products, supplemented with variable probiotic strains, like *Lactobacilli* and *Bifidobacterium* strains is yogurt.

Yogurt is a coagulated milk product, that results from the fermentation of lactic acid in milk, by (LAB) bacteria *Lactobacillus bulgaricus* and *Strepetococcus thermophilus* (Pelczar *et al*., 1986). Its traditionally manufactured by fortifying whole or skimmed milk by evaporation, or addition of skim milk powder, heating to 85-95°C for 10-30 min and inoculating with (LAB) Bacteria and then incubating at 42-45°C. Bifidus yogurt prepared, by the addition of *B.bifidum* and *B.longum*, to the yogurt culture and incubating at 42°C for 3-4 h. *L.acidophilus* can also incorporate with yogurt Culture to create acidophilus yogurt (Mazza, 1998).

The biological activity of (LAB) bacteria used in the production of cultured diary product and their metabolites, the processing steps such as pasteurization, microfiltration and product formulation, modify the physiological activity of the final product (Mazza, 1998). National Yogurt Association rules, define the active culture yogurt as a final product that contains live (LAB) bacteria in amount $\geq 10^8$ cells/g at the end time of the manufacture. Diary products such as milk, cheese and yogurt have been recognized as excellent sources of vitamins and minerals including riboflavin, phosophorus and calcium (Table 1) (Mazza, 1998).

Up to date, many research studies focused on the role of probiotic Including (LAB) bacteria in the yogurt for the enhancement of the gastrointestinal function through increasing minerals absorption, reduction in lactose intolerance (lactase deficiency) and through consumption of *L. acidophilus* culture yogurt (Vesa *et al*., 2000, Martini *et al*., 1991). LAB bacteria enables the inhibition of the Pathogen infection through production of

Table 1: Milk and diary products as sources of important nutrient

Component	Protein	Calcium	Phosphorus	Riboflavin
Unit	%	%	%	mg%
Whole milk	3.30	0.12	0.10	0.17
Cheddar cheese	25.4	0.72	0.50	0.45
Cottage cheese	12.6	0.08	0.14	0.24
yogurt	4.30	0.16	0.13	0.21
Ice cream	4.40	0.15	0.11	0.25

acetic acid, lactic acid and bacteriocins (Bianchi-Salvadori, 1986) as well as stabilizing the intestinal microflora after long term antibiotics uses (Brown *et al*., 2005).

Suppression of the harmful carcinogens associated with colon cancer (Tavan *et al*., 2002; Wollowski *et al*., 1999) and increasing the immune response by Production of secretory immunoglobulin were achieved (Perdigon, 1995, 2003). Relief of Constipation, reduction of serum cholesterol (Jones, 2002), allergy in young adults (Piaia *et al*., 2003) and control of diarrhea were established through the consumption of yogurt (Heyman, 2000). Among adults, life expectancy was the highest in the world and the rate of coronary heart disease, cancer, and other diet related chronic disease, were among the lowest, in which yogurt is considered the main source of diary products in the Mediterranean diet, incorporated with other healthy foods (fruit, vegetable, brown bread, cereals and olive oil) (Willett *et al*., 1995).

MATERIALS AND METHODS

This study aimed at reviewing most of the information related to the Probiotic as basic cultures incorporated in yogurt production. Significant Information will be mentioned about (LAB) identity, their habitats, the mechanisms of their action in improving the immunity of the host and enhancing the function of the gastrointestinal tract, through the following:

- Review the information represented in the studies, which focused on the role of yogurt on the health and function of the gut.
- Epidemiological studies, testing the effects of different probiotics culture including (LAB) bacteria in preventing certain gastrointestinal disease, will be discussed. -Data collected from recent scientific journals will be viewed.

RESULTS AND DISCUSSION

Physiological properties of LAB bacteria: LAB bacteria are gram positive, non-spore, catalase-negative bacteria characterized as fastidious, acid-tolerant and fermentative microorganisms. (LAB) bacteria are associated with habitats rich in nutrients, such as food products and plant materials. Particular (LAB) are inhabitant, human oral cavity, Vagina and gastrointestinal tract, through which *Lactobacillus, acidophilus, L.jonsonii* and *L.casei* groups are the most associated to the intestinal tract (Holzapfel *et al*., 2001) The functional properties and safety of (LAB) strains are mentioned in (Table 2).

Nutritional value of yogurt: Nutritional value of the final deducts depend on the milk-based Sources (mammalian type, feed, age and lactation stage) and processing Factors (temperature, heat duration and storage condition). Also the type Of probiotic strains used in the fermentation, directly influences the nutritional and physiological value of the final yogurt product (Mazza, 1998).

Vitamins: Dairy products are considered a major source of vitamins, including vitamin B-6, Vitamin B-12, riboflavin, niacin and folic acid. Folate is one of the B vitamins that some (LAB) species can synthesize (Kneifel *et al*., 1992). Various bacterial species were also used for milk fermentation and yogurt production was examined for its ability to synthesize or utilize folate. *S. thermophilus* and *Bifidobacteria* were folate producer, while *Lactobacilli* depleted folate from the milk media. Fermentation using combination of *Bifidobacterium animals* and *S. thermophilus* result in six-fold increase in folate concentration (Crittenden *et al*., 2003).

Lactose: Dairy products are one of the sources of disaccharide lactose in human diets. Before absorption, lactose is hydrolyzed by the intestinal brush border B-galactosidase (lactase) into glucose and galactose. (LAB)bacteria present in yogurt, Such as *L. bulgaricus* and *S. thermophilus*, expressed functional lactase that can hydrolyses 20-30% of the lactose, which contribute to better tolerance of lactose in yogurt than that of milk, by person with lactose maldigestion (Vesa *et al*., 2000 and Martini *et al*., 1991).

Minerals: Dairy products like milk, cheese and especially yogurt provide 3-4 fold of calcium consumed in the diet. Yogurt is considered as the most concentrated source of this essential mineral and others like potassium, magnesium, phosphorus and zinc (Kerry *et al*., 2001). Calcium plays a role in bone formation and mineralization, as its needed during growth, pregnancy and lactation, Average Recommendation Dietary Allowance (RDA), for calcium intake is about 900 mg/day for adult, rising to 1200

Table 2: Successful LAB strains and their functional properties

Property	*Lactobacillus casei Shirota*	*Lactobacillus rhamnosus* GG (ATCC 53103)	*Lactobacillus johnsonii* LA1	*Lactobacillus acidophilus* NFCB 1748
Origin	Human	Human	Human	-
Safety	Verified	Verified	Verified	Verified
Acid stability	Good	Good	Good	Good
Bile stability	Resistant	Resistant	Resistant	Resistant
Colonization	-	+	+	-
Bacteriocin production	No	-	Yes	No
A dherence (Caco-2)	No	Yes	Yes	No
Adherenc (mucosa)	-	Yes	Yes	Yes

mg/day for adolescent and elderly people (Gueguen and Pointillart, 2000). Calcium in yogurt is better absorbed than in milk, because this fermented product is well tolerated by Lactase-deficient people (Smith *et al*., 1985). Low calcium intake is responsible for low bone density and extensive lactose maldigestion that can elevate the risk of osteoporosis. A dietary management strategy for lactose maldigesters is to increase the calcium consumption from dairy foods, including yogurt (Kerry *et al*., 2001). Lactose enhances the absorption of calcium, magnesium and zinc (Gueguen and Pointillart, 2000).

PH: The acidic PH of yogurt ionizes calcium and thus facilitates the absorption of calcium in the intestine (Bronner and Pansu, 1999). Low PH of yogurt reduces the inhibitory effect of phytic acid on calcium bioavailability, Vitamin-D plays a major regulatory role in intestinal and proximal jejunum requires calbindin-D, vitamin D-dependent calcium-binding Protein (Norman, 1990). Diary products such as milk and infant formula are fortified with vitamin D, with 2.5 mg (100 IU) Vitamin D/237-ml, unlike yogurt that is not fortified with vitamin D. Many studies focused on the effect of yogurt-derived calcium on bone mineralization. The bioavailability of calcium in yogurt is greater than other diary products, and yogurt may increase bone mineralization more than nonfermented milk products do (Gueguen and Pointillart, 2000).

Protein: Dietary protein quality is influenced by several factors, like amino acid composition, nutritional value, and physiological properties. Protein content in yogurt is higher than that of milk, due to the addition of nonfat dry milk during processing. Even this protein is easily digested in the yogurt than that from the milk, due to the activity of (LAB) bacteria proteolysis enzymes such as peptidases which increase the final concentration of free amino acid proline and glycine in the final product (Bos *et al*., 2000). Some bacterial cultures have been shown to have more proteolytic activity than other. *L. bulgaricus* has a much higher proteolytic activity during milk fermentation than S. thermophilus, as indicated by increasing the concentration of peptides and free amino acid in the fermented yogurt (Omer Turki Mamdoh Ershidat and Ayman Suliman Mazahreh, 2009). The additional health benefits of yogurt releases of bioactive peptides such as casein, lactoferrin, serum albumin, -actoglobulin, enhance the growth of gut microflora (Piaia *et al*., 2003). Micelles of casein fraction and whey protein fraction, are of great source of all essential amino acid that are needed for tissue growth and maintenance (Bos *et al*., 2000). Proteolysis occurring during fermentation may lead to formation of novel peptides during gastrointestinal digestion. Milk fermentation by *lactobacillus helveticus*, releases some amino acid in the gastrointestinal tract and modifies the protein elution profiles obtained after digestion with trypsin (Matar *et al*., 1997).

Lipids: The consumption of dairy fat leads to the increase of the concentration of Conjugated Linoleic Acid (CLA), a long-chain bio-hydrogenated derivative of linoleic acid, in both human milk and adipose tissue (Jiany *et al*., 1999). Yogurt contains higher concentration of (CLA), than does the milk from which the yogurt was processed. CLA was reported to have anticarcinogenic properties against breast and colon cancer cells, by inhibiting the expression of cyclins and halting the progression of the cell cycle from G1 to S phase. In addition (CLA) induced the expression of the tumor suppressor p 53 (Kemp *et al*., 2003). Production of short-chain fatty acids (acetate. Butyrate and propionate, as a result of indigestible carbohydrates by colonic bacteria, in presence of fermented dairy milk, may reduce the circulatory serum cholesterol Concentration, by inhibiting hepatic cholesterol synthesis, or by redistributing cholesterol in plasma to liver (Jones, 2002). Consuming of yogurt active (LAB) bacteria, stabilizes the level of total (LDL) Cholesterol in the blood (Water *et al*., 1999).

Benefits of (LAB) bacteria in yogurt on the gastrointestinal function and health: Yogurt and (LAB) bacteria contribute to several factors that enhance the gut function and health: the make of gastrointestinal flora, the immune response against pathogens. Gut microflora plays a major role against exogenous infectious bacteria through colonization resistance. Most of the bacteria that cross the barriers of stomach and

small intestine will be live, metabolically active and colonized with in the gut ecosystem (Bourlioux *et al*., 2003) Some of these bacteria are useful to the host health, such as *Bifidobacterium* and *Lactobacillus*, which are the most dominant genera in the intestinal tract, others are harmful and cause disease to the host. Selection of strain of Bifidobacteria (*B. infantis, B.bifidum, B. adolescentis, and B.longum*) as a probiotic, to be included in fermented milks, has been based on the survival in the final product and through the intestinal tract (Holzapfel *et al*., 2001). *B. animalis B. adolescentis* were reported to have a high survival rate during intestinal transit, able to contact the epithelial cells of small and large intestine and induce lisosomal activation of the epithelial enterocytes (Perdigon *et al*., 2003). The ability of (LAB) bacteria to bin to the intestinal brush border tissue, leads to preventing pathogen from accessing the gastrointestinal mucosa, (Bernet *et al*., 1994). Such binding, is influenced by certain adhesion sites with in the intestinal lumen for the bacteria to be contact. These sites are genetically controlled by the host (Bourlioux *et al*., 2003) LAB bacteria can adapt the host intestine and survive against gastric PH, digestive enzyme and bile Salt (Alm and Pettersson, 1980). LAB species differ in their ability to survive in the gastrointestinal tract. In the group of elderly patients with atrophic-gastritis and hypochlorhydria, *Lactobacillus gasseri* survived passage through the gastrointestinal tract, but *S. thermophilus* and *L. bulgaricus* were not recovered (Pedrosa *et al*., 1995). *L.casei* present in the fermented diary product, able to survive in the intestine of human flora-associated mouse model and initiate new protein synthesis during its transit with the diet, that influence human health related to that protein (Oozier *et al*., 2002). Association of *L.casei* with yogurt starters (LAB) bacteria in the fermented milk, increase the activity of glycolytic enzyme, B-galactosidase, improved for lactose digestion and a B-glucosidase, needed for the fermentation of resistant starch, which lead to butyrate production, that improved bowel habits and increase stool output (Djouzi *et al*., 1997) The ability of (LAB) bacteria to avoid the gastrointestinal invasion of pathogenic microorganisms has been reported. *L.acidophilus*-mediated inhibition of the adherence and the entry of enteropathogenic *Escherichia* coli and *Salmonella typhimurium* to the enterocyte cell-line Caco-2 cells (Bernet *et al*., 1994). Also the similar inhibitory effects for tow strain of *Bifidobacteria* (*B. breve* and *B. infantis*), were observed (Bernet *et al*., 1993) The important defensive line of the instestine is based on three essential constituent; gut microflora, mucosal lymphoid barrier and the innate immune system gut-associated mucosal lymphoid tissue (GALT). GALT is divided into inductive and effector sites. The inductive sites are in the Peyers patches (aggregate glands), which consist of large lymphoid follicles in the terminal small intestine. Specialized transport cells (M cells) and dendrite cells (macrophages) which were found in the epithelial layer of the patches, can phogocytose soluble antigens and pathogens bind to such layer (Bourlioux *et al*., 2003). The gut microflora (*Bifidobacteria* and *Lactobacilli*) plays an important role into protecting the mucosal surface from pathogens, avoiding their attachment and entry into the intestinal mucosa (Perdigon *et al*., 2003). Also the interaction of (LAB) with the mucosal epithelial lining of the gastrointestinal tract, as well as with the lymphoid cells residing in the gut, have been suggested as the most important mechanism by which (LAB) enhance the gut immune response against ingested pathogens (Bourlioux *et al*., 2003). Sixteen strains of Lactobacillus isolated from humans, mice and food product were screened for their capacity to associate with Peyers patches in mice. *Lactobacillus fermentum* exhibits a perferntial binding to the follicle-associated epithelium of the Peyers patches (Plant and Conway, 2001). As well for *Bifidobacterium animalis* which demonstrated by fluorescent labeling techniques, able to interact with the immune cells of Peyers patches of small intestine and with the large intestine (Perdigon *et al*., 2003) The affecter component of the mucosal immune system is the secretory immunoglobulin A (sIgA). It inhibits the colonization of pathogenic bacteria in the gut, as well as the mucosal penetration of pathogenic antigen. Many studies focused on the role of (LAB) bacteria for modulating IgA concentration in the gut. Orally administered *L.acidophilus* and *L.casei* and the feeding of yogurt increased both (IgA) production and the number of lamina propria B cells that secrete (IgA) in the small intestine of mice. Yogurt is able to inhibit the growth of the intestinal carcinoma by increasing the activity of (IgA, T cells and macrophages) (Perdigon *et al*., 1995). Modulation of cytokine production by yogurt and (LAB) has been investigated. In addition to interleukin (IL)-1B and Tumor Necrosis Factor (TNF) a, which are produced by macrophages. T lymphocytes (Th1) and (Th2) helper cells, upon activation were able to produce 2 patterns of cytokines (Mossmann *et al*., 1986) .Th1 cells produce interferon- (IFN-) and IL-2. IFN-y improves induction of other cytokines and in mediation of macrophage and natural killer cell activation. TH2 cells augment humoral immunity through production of IL-4, IL-5,IL-6 and IL-10 cytokines. The production of IFN- y *in vitro* culture using human lymphocytes was reported to be greater in the presence of LAB (*L. bulgaricus* and *L. thermophilus*), than in culture with out LAB.

The most important targets for the functional food are the gastrointestinal function, including those that control transit time, bowel transit and mucosal motility, as well as those that modulate epithelial cell proliferation, balancing colonic microflora and influencing gastrointestinal immune system. Combination of

probiotics and prebiotics within diary products, improves growth and the survival of gut microflora, *Bifidobacteria*, and *Lactobacilli*, is considered a therapy that enhances their effect in the large bowel (Roberfroid, 2000). Combination of two probiotic strains *L. gasseri* and *L. coryniformis* in the diary fermented product, instead of *L. bulgaricus* yogurt strain, were able to survive in the intestine and recorded in high level in the feces of volunteers. Orally intake of probiotic strains, increases the concentration of fecal lactic acid bacteria, thus improving the fecal moisture, frequency and the volume of the stool (Olivares *et al*., 2006).

Yogurt and disease of the gastrointestinal tract
Lactose malabsorption: Lactose malabsorption involves a reduction of lactose activity in the intestinal brush border of mammals as they age after weaning. The ingestion of dairy Products containing lactose leads to symptoms of lactose intolerance, such as bloating flatus, abdominal pain, abnormal gas and diarrhea (Shermak *et al*., 1995). Lactose in yogurt is better digested than lactose in other dairy food by lactose intolerance individuals, due to the intra-intestinal activity of the yogurt (LAB) -galactosidase (Martini *et al*., 1991). Most of (LAB) bacteria which are used in milk fermentation, including *L. bulgaricus* and *S. thermophilus*, can exert their lactase activity *in vivo* in the gut lumen of both adults and children, thus facilitating digestion and alleviating intolerance (Shermak *et al*., 1995). *L. acidophilus* able to modify the lactose fermentation, by human colonic microflora in vitro in lactose maldigesters. Furthermore (LAB) can resume the activity of colonic microflora that has been disrupted after diarrhea, or antibiotic administration (Jiang and Savaiano, 1997).

Diarrhea disease: Microbial balance is an important factor in the maintenance of intestinal homeostasis, live microbial supplementation (yogurt or fermented milk). Have been proposed as healthy foods to control diarrhea as a result of lactose malabsorption, acute viral and bacterial diarrhea, as well as for antibiotic-associated diarrhea (Heyman, 2000).

Colon cancer: According to the National Cancer Institute (2002), cancer of the colon or rectum (colorectal) cancer, is the fourth most common cancer in men and women in United States (NCI, 2002). Fermented dairy products, that contain probiotics and include (LAB) in yogurt, have shown an inhibitory effect on colon cancer. Heterocyclic Aromatic Amines (HAA) that are produced during the cooking of food with high creatine, free amino acid and sugar content, are known as an initiating agent of colon cancer in animals and human (Tavan *et al*., 2002).
Tavan *et al*. (2002) studied the protective effect of probiotics in the fermented milk, on male F344 rats, which were used as a model of HAA-induced colon carcinogenesis. Different dairy sources that are able to decrease the incidence of colonic crypts in rats are as follows: 66% inhibition with milk-Supplement diet, 96% inhibition with Bifidobacterium animalis. Fermented milk-supplement diet and 93% inhibition with Streptococcus thermophilus fermented milk-supplement diet. Decrease in HAA metabolism, fecal mutagenicity and colon DNA lesions were observed. This effect being pronounced in case of milk-fermented by (LAB), against 1,2-dimethylhydrazine (DMH)-induced colon carcinogenesis. Oral treatment with Lactobacillus bulgaricus against DMH-induced DNA damage in the colon *in vivo*, whereas S. thermophilus were not effective. However, *in viirto*, both strains prevented DNA damage of N-methyl-N-nitro-N-nitro-soguanidine (MNNG) carcinogen, in isolated primary rat colon cells (Wollowski *et al*., 1999).

Inflammatory bowel disease: Inflammatory Bowel Diseases (IBD) refers to a certain chronic immune-mediated condition that is characterized by acute intestinal inflammation. These chronic diseases include (ulcerative colitis, Crohn disease and pouchitis), which result from abnormal host response to some member of the intestinal flora, or from a detective mucosal barrier (Podolsky, 2002). Normally, a healthy mucosal barrier provides a first defense line against pathogens. Proportions of different intestinal microflora are altered in patients with (IBD). Colonic biopsy specimens have shown lower concentration of Lactobacillus and lower fecal concentration of both Lactobacillus and Bifidobacterium species in patient samples. Such reduction in the intestinal microflora, as well as for TNF-a pro-inflammatory cytokine, will increase the opportunity for colonization of pathogens (Borruel *et al*., 2002). Abnormal activation of mucosal T-lymphocytes against enteric bacteria is the key event triggering intestinal inflammation. *Lactobacillus casei* is able to reduce the number of activated T-lymphocytes in the lamina propria of Crohn disease, which may restore the immune homeostasis (Carol *et al*., 2006).

Conclusion and recommendations: Its believed that consumption of yogurt including active (LAB) and other fermented dairy products provided with probiotics, enhance the function of the gastrointestinal tract. Many studies of the possible health benefits of yogurt in protecting against gut-associated disease substantiate some of these beliefs. One of the most interesting preventive effects is the protection against IBD and colon cancer as suggested by epidemiologic evidence and animal studies and the therapeutic action of diarrhea caused by infectious pathogens, in addition to the beneficial effect of yogurt containing live and active culture on the digestion of lactose in patients who suffer from lactose intolerance. These findings are interesting and should encourage future studies to investigate the

mechanisms of action through which yogurt exerts its effects and the critical components in yogurt that control such action.

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