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Hypocholestorolemic effects of probiotic yoghurts

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ABSTRACT

Cardiovascular disease is one of the most important reasons of death in the world and high levels of cholesterol is concerned as an essential risk factor for cardiovascular disease, thus a decrease in serum cholesterol levels can decrease cardiovascular disease. One preventative approaches for reduction of serum cholesterol levels could be caused by consumption of yoghurt containing probiotic bacteria. Probiotics are live microorganisms that provide health benefits when ingestion. There are a big number of probiotics presently utilized and accessible in dairy fermented foods, particularly in yogurts. Lactic acid bacteria represent a varied group of organisms given significant benefits to people, some as usual population of the intestinal area. This review presents relevant information on probiotics such as the definitions and characteristics of probiotic bacteria, their utilization in yogurt preparations, and the claimed benefits of the ingestion of these bacteria, particularly on lowering hypercholesterol.

Keywords: Probiotic, Yoghurt, Health, Hypocholestorolemic, Diseases

1 INTRODUCTION

The major cause of morbidity and mortality in the world is cardiovascular disease (Alhaj, Kanekanian, Peters, & Tatham, 2010). Cholesterol is required for certain hormones and vitamin formation, being an essential component of nerve cells and cell membranes. It is one of the danger causes for cardiovascular syndrome as well as other chronic health conditions including arthrosclerosis. However, (Manson, et al., 1992) have shown that 1% decrease in serum cholesterol level may decrease cardiovascular disease risk to about 3%.

Just as cholesterol is required to maintain body fluids and for other purposes, our dietary food intake may also impact on the composition of our plasma lipids. One intervention measure aimed at maintaining a disease free condition is to manage and/or control triglycerides and blood cholesterol levels in our diet with drug treatment, for example the use of statins (El-Gawad, El-Sayed, Hafez, El-Zeini, & Saleh, 2005 Pereira & Gibson, 2002a). Other interventions to reduce blood cholesterol include consumption of foods low in fat and cholesterol (Lora, Morse, Gonzalez-Kruger, & Driskell, 2007), probiotic bacteria (Schaafsma, Meuling, van Dokkum, & Bouley, 1998) and dietary fibre (Theuwissen & Mensink, 2008).

Although a great deal of information has shown that probiotic cultures provide countless health benefits (Gomes da Cruz, Alonso Buriti, Batista de Souza, Fonseca Faria, & Isay Saad, 2009) such as reducing gastrointestinal disorders, it can also decrease cardiovascular disease risk. Attention in the commercial and scientific fields has been focused on the use of probiotic bacteria as a consequence of the diverse beneficial effects of these bacteria on humans. Probiotics are living microorganisms, which after consumption in certain amounts are capable of promoting the health of the host beyond normal nutrition (Begley, Hill, & Cormac, 2006). They form a fraction of the components in food products as supplements. Probiotic bacteria have been used for years in food fermentation such as yoghurt which considered the best-known food for probiotics because of its own physico-

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chemical and functional characteristics (do Espírito Santo, Perego, Converti, & Oliveira, 2011).

Probiotic bacteria are live microorganism that are able to establish themselves in the gastrointestinal tract of the host organism and play pivotal roles in human health support, preventing gastroenteric pathogens (Gaggia, Di Gioia, Baffoni, & Biavati, 2011 Sánchez, Ruiz, Gueimonde, Ruas-Madiedo, & Margolles, 2012) including *Campylobacter jejuni*, *Clostridium difficile*, rotavirus and *Helicobacter pylori*, encouraging overall immune system responsiveness, avoiding intestinal dysfunction and decreasing plasma cholesterol levels (Apostolidis, Kwon, Shinde, Ghaedian, & Shetty, 2011 Tannock, 1999 Xiao, et al., 2003). It has been reported that consumption of probiotics with dairy products decreases lactose intolerance symptoms in humans (Vrese & Schrezenmeir, 2008). Probiotic reduced diarrhoea's severity and establishing mucosal cell immune defences in the intestine via specific and non-specific inflammatory reactions (Isolauri & Salminen, 2008 Johnston, Supina, Ospina, & Vohra, 2007), they may also impact on lipid and blood glucose levels (Fabian & Elmadfa, 2007 Parvez, Kim, Lee, & Kim, 2006).

Research has assessed the effects of probiotic bacteria on serum lipid profiles. Although the mechanism of cholesterol lowering by probiotic bacteria is as yet unobvious, several theories have been suggested to describe the hypocholesterolemic activity of probiotic bacteria and bioactive peptides resulted by their proteolytic activities. Probiotic bacteria could ferment non-digestible polysaccharides in intestinal lumen to result short chain fatty acids (SCFAs) such as propionic acid, which is capable of reduing hepatic cholesterol synthesis. Probiotics are capable of inhibiting intestinal cholesterol absorption by binding bile acids and cholesterol to probiotic bacterial cells, resulting in absorption of cholesterol by probiotic bacteria ((Liong & Shah, 2005 Pereira & Gibson, 2002a).

Probiotic bacteria promote cholesterol excretion through the faeces by mean of its electrostatic and hydrophobic interactions with particular peptides. Notwithstanding the beneficial health effects of probiotics, they also are capable of meeting targets required for their marketability such as viability and or maintenance of product durability during storage (Al-Sheraji, et al., 2012b). The count levels of probiotic had been recommended to be above 10^6 cfu/mL per daily dose (Kurmann & Robinson, 1991) to avoid washout, and to assure that their benefits will be accrued in a sustained manner (Peres, Peres, Hernández-Mendoza, & Malcata, 2012).The viability of probiotic organisms in yogurt is influenced by several factors such as the pH of the medium, culture strain, oxygen content, water activity, storage temperature, starter cultures and interaction between probiotics (Champagne, Raymond, & Tompkins, 2010 Gilliland, Reilly, Kim, & Kim, 2002 Heller, 2001 A. Talwalkar & Kailasapathy, 2004 Walldius & Jungner, 2004). The present paper provides a background and reviews the present literature relating to probiotics with emphasis on their health benefits. Areas covered include the definition of probiotics, properties of probiotics, viability of probiotics in yogurt during fermentation and storage, effects of probiotics on yogurt properties and their significance for human health, particularly in cardiovascular diseases.

2 PROPERTIES OF PROBIOTICS:

The best description of an excellent probiotic and therefore as criteria for the choice of

novel probiotic organisms is as following.

- Species compatibility (preferably probiotic planned for human being have to be taken from human gut, since those taken from diverse sources are normally less effective).
- The capability to stay alive during the gut and get to the intestines in a survival condition.
- Excellent ability to stick on to the intestinal epithelium.
- A short production period so they are able to settle the gut quickly.
- Production of antimicrobial factors that will slow down the increase of pathogens.
- High-quality viability in foods or additives so they have a rational shelf life in products.
- No inherent pathogenicity (present probiotics are commonly known as secure and are non-pathogenic and non-toxin-producing organisms).

1. Antigenotoxic properties (the aptitude to decrease mutation and carcinogenesis, for instance by lowering the production of mutagenic materials by other organisms in the gut)

Common strains of probiotics:

The mainly frequent species of probiotics are accessible in dairy products and probiotic-fortified foods. Nevertheless, tablets, capsules, powdered and sachets holding the probiotic in lyophilized type are obtainable. Table 1 shows most common strains of probiotics.

Viability of probiotics in yogurt during fermentation:

The viability of probiotic bacteria such as *L. acidophilus* and *Bifidobacterium* spp. was found to increase in yogurt during the production process; however, the number of *L. casei* decreased during yogurt production, while *L. casei* E5 and E10 raised around 2 times and *B. longum* S9 amplified around 3 times but *B. longum* Com did not raise (Gilliland et al., 2002). The viability of 2 bifidobacteria strains, RBL 00079 and RBL 00064, increased during yogurt production, and the growth of *L. rhamnosus* GG and *L. johnsonii* La-1 also increased 2 logs when these probiotic microorganisms were added at the same time together with the yogurt culture in cow's milk. In addition, the numbers of 2 bifidobacteria strains, RBL 00079 and RBL 00064 increased notably in cow's milk through yogurt manufacture due to the hydrolysis of milk proteins to yield free

Table 1. The most common strains of probiotics.

Strain	Brand name	Producer
Bifidobacterium animalis DN 173 010	Activia	Danone
Bifidobacterium animalis subsp. lactis BB-12	N.A.	Chr. Hansen
Bifidobacterium breve Yakult	Bifiene	Yakult
Bifidobacterium infantis 35624	Align	Procter & Gamble
Bifidobacterium lactis HN019 (DR10)	Howaru Bifido	Danisco
Bifidobacterium longum BB536	N.A.	Morinaga Milk Industry
Escherichia coli M-17	ProBactrix	BioBalance
Escherichia coli Nissle 1917	Mutaflor	Ardeypharm
Lactobacillus acidophilus LA-5	N.A.	Chr. Hansen
Lactobacillus acidophilus NCFM	N.A.	Danisco
Lactobacillus casei DN114-001 (Lactobacillus casei Immunitas(s)/Defensis)	Actimel/DanActive	Danone
Lactobacillus casei CRL431	N.A.	Chr. Hansen
Lactobacillus casei F19	Cultura	Arla Foods
Lactobacillus casei Shirota	Yakult	Yakult
Lactobacillus paracasei St11 (or NCC2461)	Lactobacillus fortis	Nestle
Lactobacillus johnsonii La1 and Lactobacillus LC1)	N.A.	Nestle
Lactococcus lactis L1A	N.A.	Norrmejerier
Lactobacillus plantarum 299V	GoodBelly / ProViva/ TuZen	NextFoodsProbiFer-ring
Lactobacillus reuteriATTC 55730&Lactobacillus reuteri SD2112	N.A.	BioGaia Biologics
Lactobacillus rhamnosus ATCC 53013 (discovered by Gorbach & Goldin(=LGG))	Vifit and others	Valio
Lactobacillus rhamnosus LB21	Verum	Norrmejerier
Lactobacillus salivarius UCC118	N.A.	
Saccharomyces cerevisiae (boulardii) lyo	DiarSafe and others	Wren Laboratories and others
Lactobacillus rhamnosus GR-1 &Lactobacillus reuteri RC-14	Bion Flore Intime Jarrow Fem-Dophilus	Chr. Hansen
mixture of 8 strains of Streptococcus thermophilus& four Lactobacillus spp& three Bifidobacterium spp strains	VSL#3	Sigma-Tau Pharmaceuticals, Inc.
Lactobacillus acidophilus CUL60 &Bifidobacterium bifidum CUL 20	N.A.	
Lactobacillus helveticus R0052 &Lactobacillus rhamnosus R0011	A'Biotica and others	Institut Rosell

amino acids by the yogurt culture. In every yogurt having *L. rhamnosus, L. johnsoniiLa-1, Bifidobacterium* RBL 00079 or *Bifidobacterium* RBL 00064, the development of the supplementary probiotic was belated for 2 to 4 h after the begin of the fermentation; that period was necessary to produce adequate amino acids to sustain bacterial growth (Farnworth, et al., 2007).

With regard to the survival of bifidobacteria during yogurt fermentation, there is a high level of *B. animalis* in yogurts containing *B. animalis*, *B. bifidum*, *B. breve*, *B. infantis*, and *B. longum* when the fermentation was stopped (4.5 h). Strains of *B. breve* and *B. infantis* were possibly more sensitive to the fermentation temperature of 44°C, but this fermentation temperature assisted develop the viability of *B. animalis* through yogurt production. *Bifidobacterium animalis* is a strain of animal source, and is stronger and more heat tolerant than other bifidobacteria of human source that has been considered (*B. bifidum*, *B. breve*, *B. infantis*, and *B. longum*). The temperature of fermentation (44°C) was unsuitable for those strains. The best temperature for viability of *Bifidobacterium spp.* of human sources is between 36 and 38°C, while that for species of animal sources is between 41 and 43°C. Viability of bifidobacteria does not happen less than 20°C, and bifidobacteria does not have thermo resistance over 46°C. As well, *B. breve* and *B. infantis* might be further responsive to acids formed through fermentation by yogurt bacteria and bifidobacteria than the other strains (Dave & Shah, 1997 Lamoureux, Roy, & Gauthier, 2002).

Viability of probiotics in yogurt during storage:

The growth of probiotics in yogurt depends on the pH of the yoghurt in addition to the species of probiotic (Gilliland et al., 2002). Although no significant ($p > 0.05$) decrease in bifidobacteria and *L. acidophilus* counts in yogurt occurred during storage (McComas & Gilliland, 2003 Akshat Talwalkar, Miller, Kailasapathy, & Nguyen, 2004), but Bifidobacteria counts in yogurt decreased more rapidly after 3 weeks and further decreased after 4 weeks of storage at 4°C (Christopher, Padmanabha, & Venkateswarlu, 2006 Ibrahim & Carr, 2006). Survival of *B. infantis*, *L.gasseri* and *L. casei* in yogurt rose after 10 days but additional storage up to 15 days reduced their survival (Haddadin, Awaisheh, & Robinson, 2004). *S. thermophilus, L. acidophilus* and *B. Bifidum* survived at levels of $>10^8$, $>10^6$ and $>10^6$ CFU/mL respectively, after storage of yogurt at 7±1°C for 4 weeks. Nevertheless, reduced viable populations of yogurt bacteria and probiotic cultures (*L. acidophilus* + bifidobacteria), down to levels of $>10^7$ and $>10^{5,}$ were noted, respectively, at the end of 30 days of storage (Dave *et al.*, 2002). Other results showed an elevated survival of probiotics, up to a level of >6 log CFU/mL (Maragkoudakis, et al., 2006) or even >8 log CFU/mL (Awaisheh, Haddadin, & Robinson, 2005) throughout storage of probiotic yogurt.

The count of probiotic bacteria was sustained more than the recommended therapeutic minimum (10^7 CFU/mL) during the storage (Krasaekoopt, Bhandari, & Deeth, 2006).

Effects of probiotics on the viability of yogurt cultures:

B. bifidum elevated the numbers of *S. thermophilus* from 8.37 to 8.42 log CFU/ mL, and *L. delbrueckii* subsp. *bulgaricus* from 8.17 to 8.28 log CFU/mL, while maintaining *B. bifidum* numbers of 8.55 log CFU/mL. *L. acidophilus* elevated the counts of *S. thermophilus* to 8.47 log CFU/mL and*L. delbrueckii* subsp. *bulgaricus* to 8.30 log CFU/ mL, while *L. acidophilus* attained numbers of 8.42 log CFU/mL. Nevertheless, *B. bifidum* numbers decreased to 8.52 log CFU/mL (Yamamah, et al., 2005); there was also an increase in viable populations of *L. delbrueckii* subsp. *bulgaricus* and *S. thermophilus* after the addition of *L. casei* to yogurt.

Effects of probiotics on yogurt properties:

The behaviour of probiotic organisms can be explained based on theireffects on yogurt properties. The production of lactic acid in yogurt increased when probiotic bacteria were used; *B. bifidum* increased lactic acid from 0.76 to 0.89% when it was used with *S. thermophilus,* and from 0.43 to 0.88% when it was used with *L. delbrueckii* subsp. *bulgaricus*. Acid production by yogurt bacteria is affected by the species; for example, *S. thermophilus* produced greater acidity with *B. adolescentis* (Khedkar, Dave, & Sannabhadti, 1994). The best incorporation was seen using *B. adolescentis* with *S. thermophilus*. The behaviour of yogurt cultures was improved after addition of *L. acidophilus* and *B. bifidum* together compared to either *L. acidophilus* or *B. bifidum* alone (Srinivas, Prabha, & Shankar, 1997). Yamamah et al. (2005) found an improvement in acidity after the addition of 5% *B. bifidum* in yogurt cultures (0.80–0.86% lactic acid); nevertheless, addition of 2% *L. acidophilus* formed low acid (0.75% lactic acid). The inclusion of probiotic cultures such as *L. acidophilus* La5, *L. acidophilus* 1748, *Lactobacillus rhamnosus* GG, *L. reuterii* SD 2112 and *B. animalis* BB12 increased lactic acid production in ultra-high temperature milk after 48 h of fermentation at 37°C (Ø stlie, Helland, & Narvhus, 2003). (Hadadji & Bensoltane, 2006) showed an increase in acidification by *B. longum* and *L. acidophilus* during mixed culturing at 45°C; however *L. plantarum* and *Lactobacillus paracasei* subsp. *Tolerans* produced minimal acid in yogurt but did not show any inhibitory action towards or from yogurt cultures (Maragkoudakis, et al., 2006).

Growth of *S. thermophilus* produced more lactic acid in yogurt than *L. delbrueckii* subsp. *bulgaricus* during storage; *L. acidophilus* and *B. bifidum* also produced an increased lactic content. Addition of *P. freudenreichii* subsp. *shermanii* or *B. bifidum*to yogurt starters also increased the content of lactic acid (Bizzozero & Sprocati, 2001). In contrast with previous results mentioned that the addition of probiotic decreased acid development in yogurt during storage (Kailasapathy, 2006). Probiotic bacteria such as *L. acidophilus* and *B. bifidum* produced yogurt with good flavour after 5h incubation at 40°C. Volatile acidity and diacetyl production in yogurt were improved when *Leuconostoc cremoris* or *B. bifidum* and *P. freudenreichii*subsp. *shermanii* were added (Sarkar & Misra, 2001). Addition of *B. bifidum* and *P. freudenreichii* subsp. *shermanii* enhanced volatile acidity and the combined diacetyl and acetoin content of yogurt. The addition of *Bifidobacterium* spp. to yogurt produced acetic and propionic acids (Adhikari, Grun, Mustapha, & Fernando, 2002). The acetaldehyde content of yogurt increased with the addition of *B. bifidum*; nevertheless, more addition of *L. acidophilus* produced less acetaldehyde content (Yamamah et al. 2005). Enrichment of milk with amino acid (threonine) improves acetaldehyde amount in yogurt has *Bifidobacterium* spp. and/or *L. acidophilus* (Baranowska, 2006). Yogurt inoculated with *L. acidophilus* MJLA1 could not be distinguished from the control sample in its flavours during storage (Heenan, Adams, Hosken, & Fleet, 2004). Probiotic yogurts showed high contents of organic acids and aroma compounds (Cruz, et al., 2012).

The addition of *L. acidophilus* and *B. bifidum* to yogurt resulted in the exhibition of higher proteolytic activity compared to either *L. acidophilus* or *B. bifidum*alone (Srinivas, et al., 1997). A greater quantity of soluble peptides is manifest in probiotic yogurt produced using yogurt culture, bifidobacteria and *L. Acidophilus*, also probiotic yogurts showed high proteolytic activity (Al-Sheraji, Ismail, Manap, Mustafa, & Yusof, 2012a Cruz, et al., 2012).

Addition of *Propionibacterium jensenii* and *B. animalis* caused an increase in the folic acid content of yogurt (Crittenden, Martinez, & Playne, 2003). *L. acidophilus* La 1 enhanced blood contains of vitamin B_{12} and folate; bio-yogurt has *L. acidophilus* La 1 and was thereby confirmed to be better than normal yogurt (Mohammad, Molloy, Scott, & Hussein, 2006).

β-galactosidase is an enzyme that hydrolyses the β-glycosidicbond formed between a galactose and a glucose molecule in lactose. Probiotic yogurt has higher levels of β-galactosidase activity than plain yogurt. Incorporation of *B. bifidum* and *P. freudenreichii* subsp. *shermanii* during yogurt making processes increased β-galactosidase activity through 7 days of storage at 8±1°C (Sarkar & Misra, 2001). Consumption of yogurt has *B. animalis* by lactose-intolerant subjects produced an important raise in the bifidobacterium numbers and decreased lactose-intolerance (Zhong, Huang, He, & Harmsen, 2006).

Health benefits of probiotics:

Several potential health benefits are in support of products including probiotic bacteria, such as antimicrobial action, improved lactose metabolism (Ankolekar, et al., 2011 Shah, 2000b), anti-mutagenic properties, prevention of cancer (Ankolekar, et al., 2011 Shah, 2007), lowering of serum cholesterol, anti-diarrhoeal properties (Shah, 2004), immune system stimulation, anti-hyperglycemia and hypertension properties (Apostolidis, Kwon, Ghaedian, & Shetty, 2007), improved mineral absorption(Ankolekar, et al., 2011 Gilman & Cashman, 2006 Mutuş, et al., 2006), reduction in inflammatory gut infection and inhibition of *Helicobacter pylori* (Apostolidis, et al., 2011 Kurmann & Robinson, 1991 Shah, 2000a, 2004). Some of these health benefits are well recognized, while others have not been demonstrated in animal studies. Nevertheless, further human trails are necessary to validate these hypotheses.

Probiotic bacteria promote the health benefits depend on the kind of strain. It is significant to mention that no single species gives all the health benefits, not even types of the same species, and not all strains of the same species will be valuable against diverse health situations. The strains *L. rhamnosus* GG, *S. cerevisiae* Boulardii, *L. casei* Shirota, and *B. animalis* Bb-12 have the significant demonstrated human health benefits regarding to lactose malabsorption, rotaviral diarrhoea, antibiotic-associated diarrhoea, and *Clostridium difficile* diarrhoea (Playne, Bennett, & Smithers, 2003) . There is sufficient confirmation to prove the report that oral ingestion of *Lactobacillus* and *Bifidobacterium* is able to sustain an ideal balance of microbial counts in the gut.

Effects of probiotics on cholesterol levels and cardiovascular risk factors:

The level danger cause for cardiovascular disease and important markers of blood cholesterol is mainly LDL-cholesterol which has been associated with a raised risk. Serum cholesterol level is affected by dietary saturated fat, cholesterol ingestion. Ingestion of fermented dairy containing probiotic bacteria (10^9 CFU /g) by hypercholesterolemic human subjects reduced cholesterol from 3.0 to 1.5 g/ L Liong & Shah (2006) M.T. Liong and N.P. Shah, Effects of Lactobacillus casei synbiotic on serum lipoprotein, intestinal microflora, and organic acids in rats, Journal of Dairy Science **89** (2006), pp. 1390–1399. View Record in Scopus Cited By in Scopus ((Shah, 2007). Probiotic bacteria are known to deconjugate bile salts: absorption of lipid by deconjugated bile acid is not as easy as its conjugated type, leading to a lowering in cholesterol level. *L. acidophilus* is also known to assimilate cholesterol throughout survive, making it inaccessible for absorption into the bloodstream (Klaver & Van der Meer, 1993). The effects of probiotics on serum cholesterol are summarised in Table 2 .

Plasma lipoprotein synthesis and metabolism:

Liver and gut consider the major organs in the body responsible for synthesis and transport of lipoproteins. The cystic duct passes bile from the gallbladder to the intestine. The liver forms the bile, but it is shifted to the gallbladder and stays there until use. When a fatty food reaches in the small intestine, bile salts are marshalled to assist with emulsification of the fats. This lets fat digestion and absorption in the intestine easy. In the epithelial cells of the intestine fatty acids, triglycerides, and cholesterol are combined and covered with a layer of protein to result chylomicrons. The body's cholesterol produces from fresh biosynthesis is less than 50%, in the liver is nearly 10%, and in the intestine is 15% (Kaplan & Pesce, 2009). "Cholesterol synthesis happens in the microsomes and cytoplasm from the two-carbon acetate group of acetyl-CoA (Dessi & Batetta, 2003) The biosynthesis of cholesterol follows these steps:

(1)Conversion of Acetyl-CoA to 3-hydroxy-3-methylglutaryl-CoA (HMG-CoA), (2)Conversion of HMG-CoA to mevalonate,

(3)Mevalonate is converted to isopentenyl pyrophosphate,

(4)Isopentenyl pyrophosphate is converted to squalene,

(5)Conversion of squalene to cholesterol (Dessi & Batetta, 2003)."

In normal adults, about 1 g of cholesterol is created and 0.3 g is ingested from food per day. The body keeps a moderately stable quantity of cholesterol (150–200 mg/dL). This is made mostly during controlling the level of *de novo* synthesis. Nutritional ingestion of cholesterol moderately controls the level of cholesterol synthesis. These cholesterols after that are utilized for the synthesis of cell membranes and in the formation of steroid hormones and bile acids (Croft, et al., 1988). "Three separate mechanisms regulate the body's constant supply of cholesterol from cells (Kaplan & Pesce, 2009).

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(1)Regulation of HMG-CoA reductase,

(2)Regulation of extra intracellular free cholesterol via Acyl-CoA,

(3)Lecithin-cholesterol acyltransferase (LCAT)"

Atherosclerotic plaque happens in the arteries by low density lipoprotein cholesterol (LDL-C) which can be oxidized by very reactive, oxidative compounds in the body that called free radicals. Atherosclerotic plaque in the body can reduce by antioxidants compounds (Jialal, 1998), such as vitamins A, C, and E, and other nutrients. Antioxidants can inhibit the formation and oxidation of free radicals. Also vitamins, A, E, and C, assist to reduce LDL-C oxidation.

High Density Lipoprotein (HDL-C) which forms also in the liver and considers different kind of lipoprotein from LDL-C and VLDL-C. It contains fewer amounts of triglyceride and cholesterol, but contains a particular protein coating. HDL-C gathers the extra cholesterol that cholesterol-metabolizing cells do not use. Unutilized cholesterols from arteries, liver, and other tissues are moved back to HDL-C by Lecithin-cholesterol acyl transferaseis (LCAT) and absorbed by HDL-C. LCAT and HDL-C can remove some oxidized LDL-C as well (Höckerstedt, Jauhiainen, & Tikkanen, 2004). The major apolipoprotein in HDL-C is Apo-A-1 which presents a main role: it gathers extra cholesterol from all cells in the body and transports it to the liver (Nissen, et al., 2003). Cardiovascular disease risk can increase if the ratio between Apo B/Apo A-1 is high due to possibility of cholesterol places in the walls of the arteries but if the ratio between Apo B/Apo A-1 is low that mean cardiovascular disease risk is low (Walldius & Jungner, 2004).

Probiotics' mechanism of action on lipids:

Probiotics bacteria ferment indigestible carbohydrates in the intestine to produce short chain fatty acids (SCFAs). However SCFAs are produced from peptides, polysaccharides, proteins, and oligosaccharides by probiotic bacteria

Table 2. Effectsof probiotics on serum cholesterol

Probiotic	Probiotic function	Reference
L. acidophilus	Lowered serum total cholesterol (TC) levels.	(Ouwehand, Salminen, & Isolauri, 2002)
L. acidophilus; L. casei ASCC 1520, ASCC 1521, ASCC 292, ATCC 15820, and L. acidophilus ATCC 4962	Assimilated more than 25 μg mL−1 TC	(Liong & Shah, 2005)
Human strain of Enterococcus faecium	Resulting the lowering of plasma TC by 0.37–0.41 mmol/L after 6 wk. Significantly larger decrease in serum low density lipoprotein cholesterol (LDL-C); concentrations decreased throughout the study.	(Agerbaek, Gerdes, & Richelsen, 1995) (Richelsen, Kristensen, & Pedersen, 1996)
Ent. faecium (Gaio)	Reduced both TC and LDL-C by 4% and 5%, respectively	(Agerholm-Larsen, Bell, Grunwald, & Astrup, 2000)
L. casei TMC 0409	Increased high density lipoprotein cholesterol (HDL-C); also reduced the levels of triglycerides (TG) significantly.	(Kawase, Hashimoto, Hosoda, Morita, & Hosono, 2000)
S. thermophilus TMC 1543	Increased HDL-C. Levels of TG were also reduced	(Kawase et al. 1999)
B. longum 913; L. acidophilus 145	Increased HDL-C content by 0.3 mmol L−1 and decreased ratio of LDL-C to HDL-C from 3.24 to 2.48 (p=0.001).	(Kiessling, Schneider, & Jahreisl, 2002)
L. gasseri SBT0270, SBT0274	Exerted hypocholesterolaemic effect	(Hosono, 2000)
L. reuteri CRL 1098 (104 cells d−1)	Resulting a 40% lowering in TG and a 20% raise in the ratio of HDL-C to LDL-C.	(Taranto, Medici, Perdigon, Ruiz Holgado, & Valdez, 1998)
B. longum BL1	Result to a significant reduction of plasma contents of TC, LDL-C, and TG.	(Xiao, et al., 2003)
L. brevis NR1C1684; Ent. faecalis	Assimilated more cholesterol	(Pereira & Gibson, 2002b)
B. lactis Bb-12 or B. longum Bb-46	Significantly lowered levels of plasma TC and VLDL-C + LDL-C and promoted faecal excretion of bile acids	(El-Gawad, et al., 2005)
Lactobacillus strains (NTU 101 and 102)	Lowered TC levels in serum and liver.	(Chiu, Lu, Tseng, & Pan, 2006){Chiu, 2006 #144}
B. animalis spp. lactis (Bb12)	Cholesterol levels were lowered by up to 48% after incubation with Bb12	(Alhaj, et al., 2010)
B. longum SPM1207	Has higher possible to be utilized as a cholesterol-reduction mean	(Shin, et al., 2010)
B. longum BB536	Reduced TC, LDL-C and VLDL in plasma of hypercholesterolaemic rats	(Al-Sheraji, et al., 2012b)
B. pseudocatenulatum G4	Decrease cholesterol levels in plasma of hypercholesterolaemic rats	(Al-Sheraji, et al., 2012b)

but in carbohydrates consider the main source of SCFAs (St-Onge, Farnworth, & Jones, 2000). Indigestible carbohydrates are hydrolyzed by a diversity of hydrolytic enzymes which are produced by probiotics and let the probiotics to ferment their sugar content. SCFAs such as propionate can reduce the levels of cholesterol in blood by inhibition the forming of hepatic cholesterol. Propionate reaches the liver by the portal vein and inhibits the cholesterol synthesis pathway by inhibiting HMG-CoA reductase (Levrat, et al., 1994), just as the statins presented inFigure 1 . It also acts to redirect plasma cholesterol towards the liver (De Preter, Coopmans, Rutgeerts, & Verbeke, 2006).

Source: (Kirk, 1999).

Combination of bile salts, cholesterol, and phospholipids produces micelles which play a important function in the absorption of cholesterol in the gut. Bile acids are produced during deconjugation of bile salts in the small intestine. Micelle production can be inhibited by bile acid hydrolase (BSH) which produces from probiotics. BSH converts conjugated bile acids to unconjugated bile salt in the enterohepatic circulation. It cleaves the peptide linkages in bile acids that link amino groups in amino acid to carboxyl groups in the bile acids during the bile acids formation from cholesterol and either glycine or taurine in the liver. The resulting unconjugated bile acids precipitate as shown inFigure 2 ; thus new bile acids is needed to produce micelles so more cholesterol is converted to bile salts in a homeostatic response, consequential the cholesterol level will decrease in blood Figure 3 (Begley, et al., 2006).

Source: (Begley, et al., 2006).

Source:(Ooi & Liong, 2010).

Probiotics deconjugate bile acids and hydrolyze bile salts by hydroxy steroid dehydrogenase, and bile acid hydrolase, thus, the bile acids' enterohepatic circulation is stopped (Ahn, Kim, Lim, Baek, & Kim, 2003 De Boever & Verstraete, 2001). Probiotic bacteria can bind cholesterol up in the small intestines, thus the absorption of cholesterol from the gut is decreased Figure 4 (Hosono, 1999)and incorporating it into their cellular membranes (Kimoto, Ohmomo, & Okamoto, 2002). Cholesterol can be taken in during growth

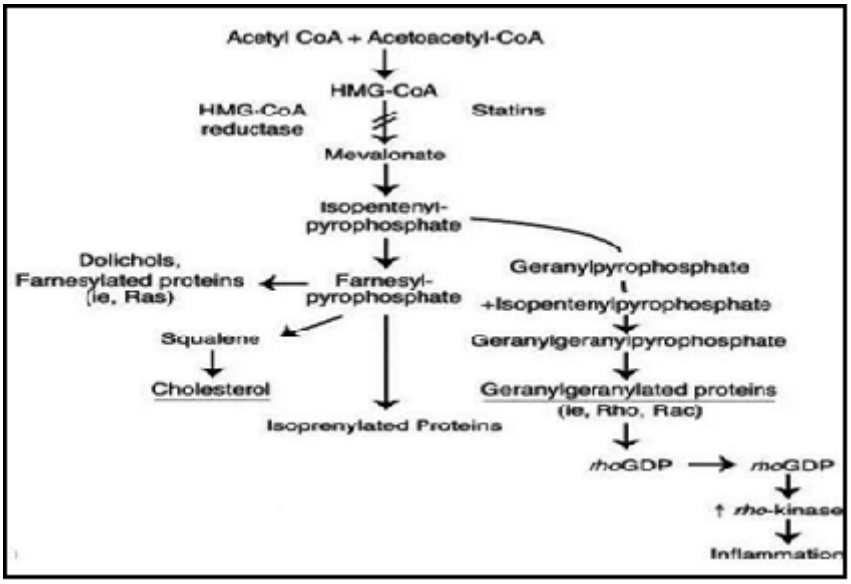

Figure 1. Inhibition of HMG-CoA reductase pathway

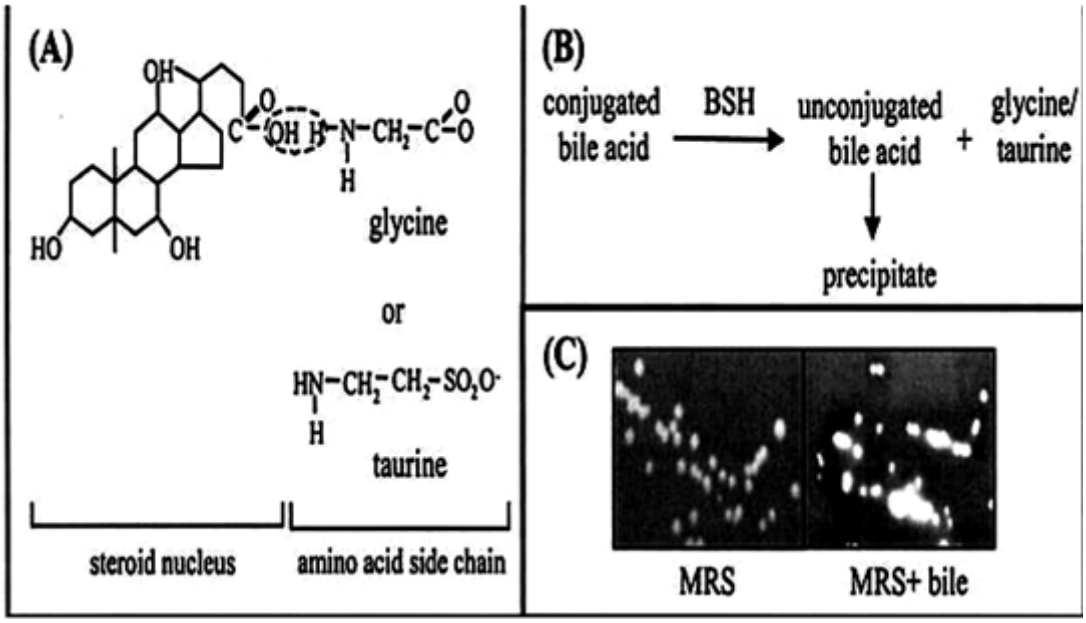

Figure 2. Bile acids precipitated byBSH pathway. BSH: bile acids hydrolase

of probiotics (Noh, Kim, & Gilliland, 1997). The previous activities of probiotics contribute to the cholesterol reducing performances.

Source:(Ooi & Liong, 2010)

3 CONCLUSIONS:

Probiotic bacteria are live microorganisms which when ingested in sufficient numbers exert health benefits such as reduction of hypercholesterol, lowering of intestine pH, formation of several digestive enzymes and vitamins, formation of antibacterial compounds, e.g., organic acids, bacteriocins, hydrogen peroxide, diacetyl, acetaldehyde, lactoperoxidase, lactones and other unidentified substances. Other benefits include contributions to reconstruction of regular intestinal bacteria after disorders resulted by diarrhoeas, antibiotic treatment and radiotherapy, lowering of cholesterol content in the serum, motivation of immune roles, inhibition of bacterial diseases, elimination of carcinogens and enhancement of calcium absorption and the decrease of faecal enzyme action.

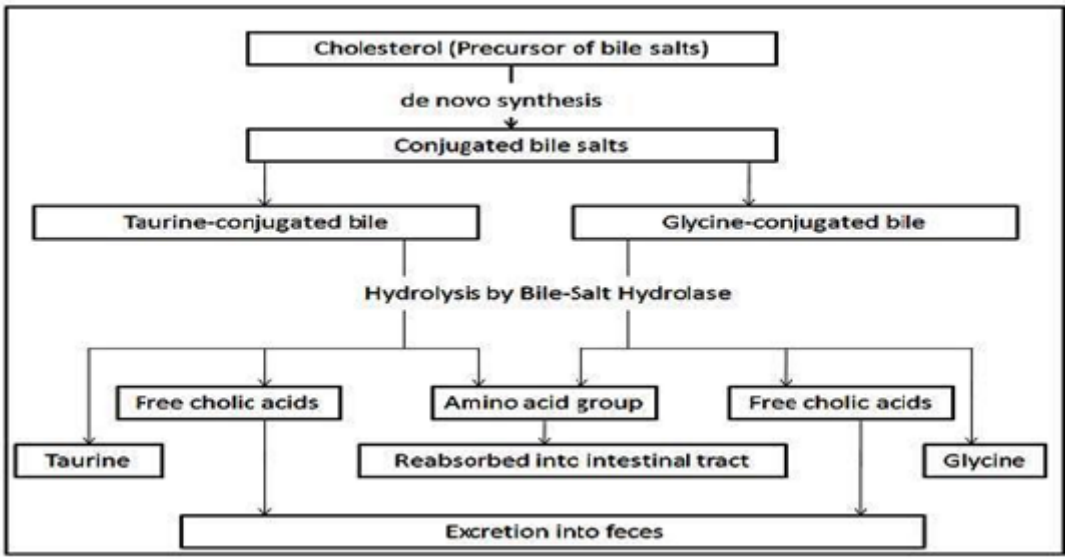

Figure 3. Cholesterol as the precursor for the synthesisof new bile acids and thehypocholesterolemic role of bile salt hydrolase

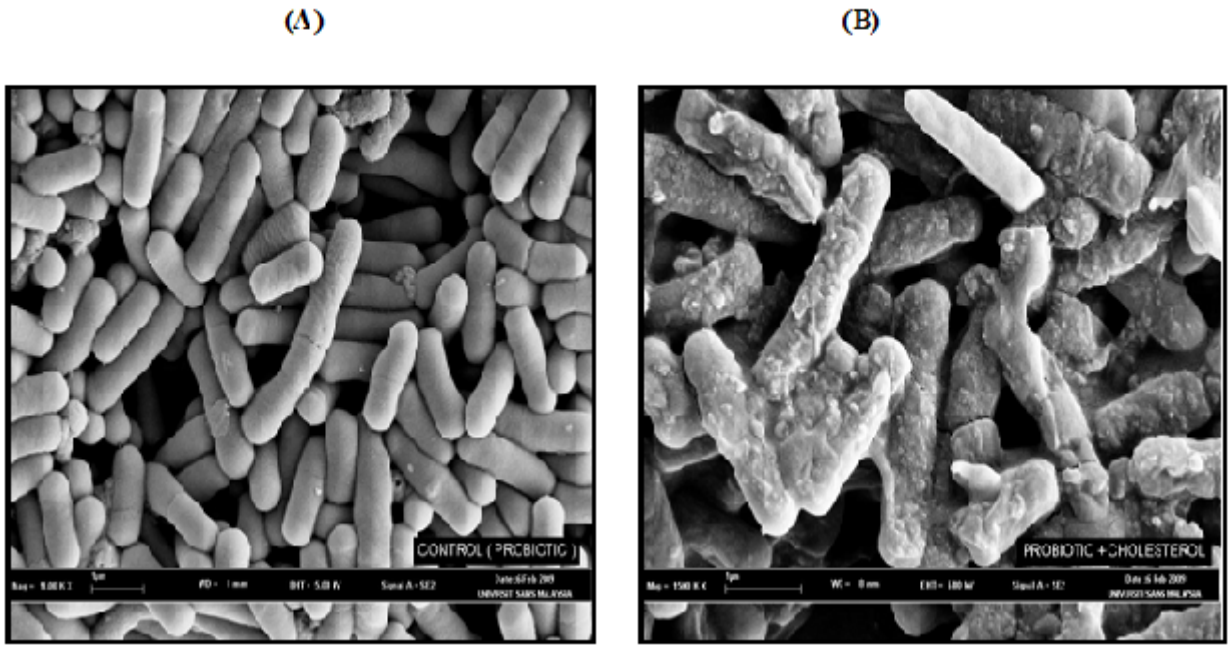

Figure 4. Scanning electron micrograph of Lactobacillus bulgaricus cultivatedin(A) media without cholesterol and (B) broth supplemented with cholesterol(100 mM)

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