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RESEARCH ARTICLE

Lacto Vegetarianism, Probiotics, and Prevention of Hypertension-A Short Review

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Abstract

The lactovegetarian diet, primarily followed throughout the Indian subcontinent, including India, Sri Lanka, Nepal, and Bhutan, is centred on plants and milk. This diet includes Polyphenols, plant and milk-based lipids, and high-fiber carbohydrates. Plant-based diets mostly promote the growth of good bacteria such as Lactobacillus, Akkermansia, and Bifidobacterium while reducing the numbers of Clostridium and Enterococcus. Probiotics have recently been the topic of scientific investigation about their ability to lower the risk of cardiovascular disease. The production of SCFAs, CLA, GABA, and ACE-inhibitory peptides by the probiotic strains Lactobacilli and Bifidobacteria has been linked to possible hypotensive effects.

Key Words: *Vegetarianism; Probiotics; Gut microbiota; Hypertension; Bifidobacterium; Lactobacillus*

Introduction

Vegetarianism is a dietary pattern based on plant-derived foods. Lacto-vegetarianism is a common dietary practice in the South Asian subcontinent, characterized by the consumption of vegetables and dairy products as staple foods. Numerous studies have linked vegetarian diets to a reduced risk of several chronic illnesses, including type 2 diabetes, cardiovascular disease (CVD), hypertension, multiple cancer types, and other illnesses [1]. In the past few decades, probiotics have become more important due to their health-promoting properties in preventing and treating gut-associated disorders, urogenital infections, and respiratory infections [2]. Probiotics boost immunity by producing neurotransmitters, vitamins, and a variety of metabolites [3] Probiotics act as therapeutic agents by producing organic acids, hydrogen peroxide, bacteriocins, bacteriocin-like inhibitory substances, short-chain fatty acids (SCFAs), conjugated linoleic acid (CLA), and gamma-amino-butyric acid (GABA) [4-11]. Probiotics have recently been the topic of scientific investigation about their ability to lower the risk of cardiovascular disease [12-15]. Lactobacilli and Bifidobacteria are two probiotic strains capable of producing

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SCFAs, CLA, GABA, and ACE-inhibitory peptides, which have been found to have potential hypotensive effects [11,16-21]. An increased intake of plant foods and increased consumption of polyphenols and fibers create a particular bacterial niche and unique metabolites with varying capacities to digest different nutrients. Studies demonstrate that vegetarians' gut flora not only carry more genes for nitrogen absorption due to their diets' lower supply of amino acids but also have a decreased capacity to metabolize carnitine providing evidence for this [22]. In one study, six obese patients with co-morbid conditions, such as type 2 diabetes and high blood pressure, were placed on a strict vegetarian diet for 30 days. After this period, the participants showed an increase in Bacteroidetes bacteria, particularly Bacteroides fragilis and Clostridium species, along with a decrease in Firmicutes and Pathobionts [23]. A separate study reported that a vegetarian diet raised the relative abundance of bacteria overall and that consuming more fiber was linked to higher populations of Prevotella organisms, which are also members of the Bacteroides species. According to data from several observational studies, a vegetarian diet may enhance bacterial diversity. Numerous investigations revealed that Prevotella, Bacteroides, and Faecalibacterium prausnitzi were rising and Enterobacteriaceae family members were declining [24-28]. According to various studies, probiotic bacteria like Bifidobacterium and Lactobacillus are enhanced by the lacto-vegetarian diet of ancient India [29,30]. Hypertension (HTN) is now a substantial risk factor for renal, cardiovascular, and cerebrovascular disorders and a global public health concern [31,32]. The development of hypertension depends on the complex interplay between environmental and genetic factors [33,34]. Recently, groundbreaking research has provided new evidence, showing for the first time that an abnormal gut microbial community is associated with variations in host blood pressure. Disordered gut microbiota (GM), characterized by an increased Firmicutes-to-Bacteroidetes ratio and reduced microbial richness, diversity, and evenness, has been observed in seven hypertensive (HTN) patients as well as in hypertensive animal models [35]. Additionally, using meta-analyses of randomized human clinical studies and rat models of hypertension, researchers have demonstrated that probiotic medication can lower blood pressure [14]. Additionally, transplanting cecal contents from high-fat diet-induced hypertensive rats with obstructive sleep apnea into recipient rats on a regular chow diet has been shown to elevate blood pressure. This suggests that gut dysbiosis plays a key role in the development of hypertension associated with obstructive sleep apnea in high-fat diet models [36].

Materials and Methods

Methodology

This narrative review investigates the effects of a lacto-vegetarian diet on gut microbiota and its role in regulating hypertension. The study synthesizes data from existing literature to provide a comprehensive understanding of the interplay between dietary patterns, microbial diversity, and blood pressure control.

Search process

An electronic search was conducted using the keywords lactovegetarian diet, gut microbiota, and hypertension in the PubMed, Web of Science, and PsycINFO databases. Books and the PsycINFO database were not included in the search a priori.

Inclusion criteria

There are two arms to the search parameters. In the first part, we used to search the effects of lactovegetarian on human gut microbiota. The second one discusses the impact of microbiota in the regulation of Hypertension. Due to the small number of studies, no restrictions were placed on this investigation.

Study selection

The first and second authors independently assessed the titles and abstracts to determine the eligibility.

Nutrients in a Vegetarian Diet and How it Influences Microbial Population

Low bioavailable foods, such as larger food particles, unprocessed meals, unpolished cereals, and pulses, are increasingly popular today. These foods contribute to the production of oligosaccharides and dietary fibers, which are deposited in the large intestine. The availability of these fibers and oligosaccharides promotes the growth of gut microbial populations [37]. The Western diet is high in ultra-processed foods, including starch, refined sugars, and trans fatty acids, which are easily absorbed in the small intestine. The lack of dietary fiber in this diet reduces the diversity and abundance of the gut microbiota [38]. A vegetarian diet rich in vitamins, polyphenols, and dietary fibers can help enhance the gut microbiota.

Carbohydrates

Digestible carbohydrates serve primarily as an energy source, while indigestible carbohydrates, such as resistant starch, cellulose, hemicellulose, pectin, and certain oligosaccharides, support the growth of intestinal microbiota. Studies have shown that digestible carbohydrates in fruits, particularly glucose, sucrose, and fructose, reduce the abundance of Bacteroides and Clostridium [39]. Non-digestible carbohydrates (dietary fibers) consistently reduce the populations of Clostridium and Enterococcus species while promoting the growth of lactic acid bacteria. Bifidobacteria, a genus in the Actinobacteria phylum, has been shown to thrive on both digestible and non-digestible carbohydrates. One study found that a diet high in fiber, fructose, and oligosaccharides increased the population of Bifidobacteria. This genus, which produces butyrate, is crucial for maintaining the integrity of the human gut barrier and protecting against illness and pathogens [38]. All oligosaccharides had a potent bifidogenic impact, and beta-glucan stimulated the development of Prevotella and Roseburia while simultaneously increasing the production of SCFA propionate inulin [40]. Additionally, this study demonstrated that SCFA levels are raised by all-natural sugars, particularly non-digestible forms such as oligosaccharides and inulin. In addition to acting as prebiotics by encouraging the growth of good bacteria, non-digestible carbohydrates also lower serum triglyceride, total cholesterol, and LDL cholesterol levels as well as the generation of proinflammatory cytokines. Therefore, non-digestive carbohydrates may offer protection against illnesses of the central nervous system and cardiovascular disease [41].

Proteins

Most studies have observed a positive correlation between microbial diversity and protein consumption [41]. The gut microbiota responds differently to plant and animal proteins. For example, individuals with a high intake of animal protein, such as beef, which is also high in fat, exhibit lower levels of bacteria such as Ruminococcus bromii, Eubacterium rectale, and Roseburia—key microorganisms involved in breaking down dietary plant polysaccharides [24]. Consuming pea protein raises intestine

SCFA levels by decreasing pathogenic bacteria, such as Bacteroides fragile and Clostridium perfringens, and increasing good bacteria, such as Bifidobacteria and Lactobacillus [41].

Fats

The quantity and quality of fat consumed have been shown to have a significant influence on the gut microbiota's makeup [42]. Mono and polyunsaturated fats, which make up a vegetarian diet, frequently increase the ratio of Bacteroides to firmicutes and the growth of lactic acid bacteria, Bifidobacteria, and Akkermansia muciniphila [41]. Nuts, particularly walnuts, have been shown to improve the gut microbiota by increasing Bifidobacteria and Ruminococcaceae and decreasing Clostridium sp cluster XIV a species [43]. Saturated derived from animal sources—increases Faecalibacterium prausnitzii and Bilophila while decreasing Bifidobacterium [41]. Saturated fat causes metabolic problems and triggers inflammation, by increasing proinflammatory cytokines such as TNF-alpha, IL-1, and IL-6 [44]. Increased Firmicutes, decreased Bacteroidetes, Bacteroides, Prevotella, Lactobacillus, and Bifidobacterium species, and an increased risk of cardiovascular diseases are all consequences of a Western diet heavy in saturated and trans fats [25,45].

Polyphenols

Plant metabolites that are naturally present include polyphenols [46]. Higher levels of Lactobacillus and Bifidobacterium in plant-based diets have anti-inflammatory, anti-pathogenic properties, and provide cardiovascular protection [41]. Polyphenols are found in tea, cocoa products, fruits, seeds, and vegetables. The polyphenols in tea extracts stimulate the growth of Bifidobacterium and Lactobacillus species, leading to an increase in the production of short-chain fatty acids (SCFAs).

Dairy Product and Gut Microbiota

Dairy products like milk, yogurt, and cheese are considered nutrient-dense, providing protein, calcium, and other essential nutrients such as magnesium, potassium, phosphorus, zinc, and B vitamins. Consuming these foods is associated with a higher-quality diet [47,48]. Dairy products fermented by beneficial microbes, which convert lactose into lactic acid and lower the pH without causing coagulation, are known as fermented milk products. Studies suggest that these fermented milk products can support the gut microbiota in healthy individuals and those with gastrointestinal disorders [49]. Research by Guerin-Danan et al. found that supplementing milk with yogurt cultures (Lactobacillus bulgaricus, Streptococcus thermophilus, and Lactobacillus casei) for one month increased enterococci levels in infant feces [50]. After eight weeks of consuming yogurt containing Bifidobacterium longum, the gut microbiota of adults also changed. Bacteroides fragilis decreased in comparison to UHT milk groups [49]. Bifidobacterium animalis was added to yogurt for 10 days, and after 30 days, the amount of Bifidobacterium, Alercreatzia [51]. Consuming fermented dairy products, such as yogurt and kefir, raised the number of Lactobacillus and Bifidobacterium bacteria [52-54]. Additionally, two studies showed that eating yogurt had preventive effects against harmful bacteria, such as Salmonella typhi and Bacteroides fragilis [52,55]. Milk and fermented dairy products may promote the growth of Lactobacillus and Bifidobacterium, which may change the gut microbiota to the host's benefit. They are regarded as probiotic species, which are known to boost host health [56]. Participants who drank bovine milk had lower levels of it than those in the control group, and there were signs that the bovine milk group had lower levels of Prevotella [57].

Role of Gut Microbiota in the Regulation of Blood Pressure

Researchers have recently shown a great deal of interest in probiotics and their possible contribution to renal and cardiovascular health maintenance. "One study found that consuming sour milk enriched with bioactive tripeptides derived from Lactobacillus helveticus LBK-16H for 21 weeks significantly reduced systolic blood pressure (SBP) by an average of 6.7 ± 3.0 mmHg in hypertensive individuals compared to the control group" [21]. Another study reports that sour milk fermented with Lactobacillus cerevisiae consisting of tripeptides reduced the mean blood pressure of men with borderline hypertension (ages 23–59) by 5.2+8.1 mmHg and the DBP by 1.7 mmHg [58]. Evidence has shown that the administration of L. casei cell lysate reduced blood pressure, triglycerides, plasma cholesterol, and the control group [59]. Oral administration of probiotic cultures Lactobacillus rhamnoses GG and Streptococcus thermophilus, including milk and vegan diet, significantly decreased rat colon coliforms and improved the lipid profile [60].In rats with spontaneous hypertension, fermented sour milk containing ACE-inhibitory tripeptides from L. helveticus delayed the onset of hypertension [61]. Intake of fermented milk with Lactococcus lactis Y-IT and L.casei by moderate hypertensive patients shows a reduction in SBP and DBP [17]. In individuals with pre-hypertension and hypertension, probiotic-fermented milk dramatically lowered both SBP and DBP [62]. The introduction of Lactobacillus johnsonii decreases renal sympathetic nerve activity and hypertension [63]. A fermented food product containing Lactobacillus plantarum 299v significantly lowered the blood pressure of 36 smokers in a six-week randomized, double-blind, placebo-controlled study. The introduction of probiotics significantly reduces the concentration of fibrinogens, LDL cholesterol, leptin, IL-6, and F2-isoprostane, in hypertensive patients [64]. Lactic acid bacteria can help modulate hypertension by breaking down complex milk proteins and releasing short bioactive peptides with ACE-inhibitory action [65-67]. Fermented soy milk rich in Lactobacillus bulgaricas, Lactobacillus acidophilus, S. thermophilus, and Bifidobacterium longum, significantly reduces SBP in rats [68]. Several studies have previously demonstrated the connection between gut microbiota and TMAO levels in the development of CVD. In a recent study, the probiotic L.casei was administered to patients for 12 weeks; the central group had higher levels of total mental age [69]. Due to the potential antihypertensive effect of probiotics, biologically active peptides derived from fermented milk have been shown to lower blood pressure in hypertensive subjects in clinical and experimental studies conducted in spontaneously hypertensive rats [70]. The tripeptides isoleucine-proline-proline (IPP) and valine-proline-proline (VPP), which are generated when lactic acid bacteria ferment milk, were the subject of the majority of investigations. These studies demonstrated angiotensin-converting enzyme (ACE) inhibitory effects in vitro. Because it inactivates the vasodilator bradykinin and transforms angiotensin I into the vasoconstrictor angiotensin II, ACE plays a crucial function in blood pressure regulation. Additionally, it has been shown that probiotics and their products can lower blood pressure by addressing endothelial dysfunction, lowering blood sugar, and lowering insulin resistance [71-73]. In contrast, a different study found that probiotic soymilk consumption significantly, but moderately, reduced blood pressure [74].

According to a recent meta-analysis, probiotic fermented milk significantly decreased SBP by 3.1 mmHg and DBP by 1.31 mmHg when compared to placebo groups. The impact of probiotics on blood pressure may also be explained by other processes, such as increased nutritional and phytoestrogen absorption (which can function as vasodilatory agents), decreased plasma glucose, and the development of inflammatory-induced diabetes mellitus [75-77] (Figure 1).

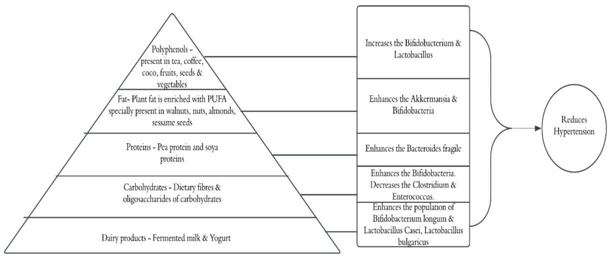

Figure 1) *How Lactovegetarian-diet enhances the bacterial population and reduces the hypertension.*

Discussion

The lacto-vegetarian diet consists of plant-based protein, fats, and polyphenols, which mainly enhances the population of beneficial probiotic bacteria like Bifidobacteria, Lactobacillus, Akkermansia, and decreases the populations of Clostridium and Enterococcus. Dairy products including yogurts increase the gut microbiota like Bifidobacterium fragilis, Lactobacillus casei, Bacteroides, and Lactobacillus bulgaricum. Hypertension is influenced by oxidative stress and gut microbial dysbiosis. In one study, 5-week-old rats with spontaneous hypertension received a 12-week course of treatment with Bifidobacterium longum. Both the diastolic and systolic blood pressures have significantly decreased [78]. The probiotics Lactobacillus 40 and Bifidobacteria in hereditary hypertension prevent microbial dysbiosis, endothelial dysfunction, and elevated blood pressure [79]. After 16 weeks of treatment, Bifidobacterium lactic M8 and Lactobacillus rhamnosus M9 reduce high blood pressure by altering the gut microbial composition in mice [80]. A decrease in the abundance of genus Bifidobacterium may be associated with lowering blood pressure in children with type 1 diabetes [81]. Nitric oxide (NO) plays a crucial role in vascular health and the development of hypertension. Typically, NO acts as a vasodilator, helping to regulate blood pressure. However, its dysregulation can lead to oxidative stress and endothelial dysfunction, contributing to hypertension.

Research indicates that treatment with Lactobacillus strains can positively influence NO pathways. By preventing gut microbial dysbiosis and reducing immune system imbalances, Lactobacillus restores microbial harmony. This, in turn, reduces vascular oxidative stress and mitigates pro-inflammatory states. Such effects help prevent early events associated with the progression of atherosclerosis and hypertension, highlighting the therapeutic potential of Lactobacillus in managing blood pressure [82]. Probiotic treatment significantly altered the cecum microbiota of Wistar Kyoto rats. There was a notable increase in the prevalence of Lactobacillus species and related clusters, while the populations of Bacteroides and Clostridium species decreased. These changes suggest that probiotics can favorably modulate gut microbial composition, potentially contributing to improved gut health and associated physiological benefits [83]. LGG therapy prevented the worsening of hypertension in model rats by reducing blood TMAO levels, regulating the Th1/Th2 cytokine balance, and inhibiting the phosphorylation of Erk1/2, Akt, and mTOR. These effects demonstrate the potential of LGG in managing hypertension through the modulation of molecular and immune pathways [84]. Considered a next-generation probiotic, Akkermansia muciniphila has been shown in numerous studies to have a beneficial effect on lowering or controlling hypertension. The emergence of hypertension may result from the decline in A. muciniphilia populations [35,85]. Anaerobic gut bacteria, highly glycosylated mucin-degrading microbes such as A. muciniphila, and saccharolytic fermentation of undigested carbohydrates are the main ways that the diet produces SCFAs [86,87]. A. muciniphila's main function is to break down the mucin in intestinal epithelial cells and provide goblet cells with carbon and nitrogen as energy sources so they can secrete mucin once again. Homeostasis should be maintained in this cycle [86]. SCFAs, including acetate, propionate, butyrate, formate, isobutyrate, valerate, and isovalerate, are formed in varying amounts in the secreted mucin, with the most prevalent being acetate, propionate, and butyrate [88]. Acetate and propionate, which are primarily secreted by A. muciniphila, regulate tight junctions and proteins including occluding, claudins, and zona occludens, strengthening the integrity of the gut barrier [89]. Initially, it was believed that SCFAs controlled blood pressure using G-protein coupled receptors (GPR41, also known as FFAT3, GPR43, also known as FFAR2) in humans and Oltr78 in mice. Furthermore, SCFAs now control blood pressure in humans via GPRR109a and OR51E2. All three of the primary SCFAs—propionate, acetate, butyrate, and the subdominant SCFA, lactate—control blood pressure in humans and animals via these receptors [90-94]. Research indicates that the intestinal bacterium Bacteroides fragilis can reduce corticosterone production by the intestinal epithelium. It does this by metabolizing arachidonic acid, a process that plays a key role in the development of high-salt hypertension [95].

Conclusion

The lactovegetarian diet is rich in plant fibers, plant-based protein, milk-based protein, plant fat, milk-based fat, polyphenols, which enhance the growth of beneficial probiotic bacteria like Bifidobacteria, Lactobacillus, Akkermansia, and decrease the populations of Clostridium and Enterococcus. Since the Bifidobacterium, Lactobacillus, and Akkermansia muciniphila have an antihypertensive role, the increased population of these bacteria also causes the prevention of hypertension.

Limitations of this Study

- The study relies heavily on secondary data from observational studies and randomized controlled trials, which may have variations in methodology and participant demographics.
- The inclusion of studies primarily supporting the positive impact of Lacto-vegetarian diets and probiotics might introduce selection bias, potentially overlooking contradictory findings.
- Many referenced studies, especially those involving human trials, have small sample sizes, which might limit the generalizability of the findings
- Variabilities in Lacto-vegetarian diets, such as differences in food sources, preparation methods, and cultural dietary habits, could influence gut microbiota composition differently, complicating standardization.
- Few cited studies track the long-term effects of dietary changes on gut microbiota and hypertension, leaving gaps in understanding the sustainability of benefits.
- Other lifestyle factors (e.g., physical activity, stress levels, medication use) that might influence gut microbiota and blood pressure are not comprehensively addressed.

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