ISSN 2959-409X

Impact and Application of Vegan Diet on Gut Microbiota

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Abstract:

Vegan diet has been more popular these years. At the same time, a serious of researches showed that the dietary pattern can affect the gut microbiota. This review mainly shows the impact of vegan diet on human gut microbiota, along with the medical apply of these impact. It illustrates that vegans have more gut microbiota comparing to omnivores. In contrast, the long-term (over 3 years) vegans have higher abundance of Clostridiales and genera Faecalibacterium, Bacteroides, Clostridium and Prevotella and the short-term (3 days to 2 weeks) vegans have more various gut environment. For the imply of vegan diet's effect on gut microbiota, it was found contributing on treating obesity,steatohepatitis, undernutrition and cardiovascular diseases. The limitation of the review is that the time, especially the long-term and short-term definition is various, causing the errors in the research analysis. Future research could combine the gut microbiota behavior with the vegan diet to create treatments or use it as a supporting diet.

Keywords: Vegan diet; gut microbiota; time.

1. Introduction

Vegan diet is a kind of dietary pattern that excluding all the animal origins, like meat, diary and honey [1]. It is a kind of high carbohydrate, high fiber, low fat diet with plant-based proteins. Since people getting more emphasizing the relationship between diet and health has also been emphasized, the number of vegans has been increased. With the amount of vegan product market reached $27.07 billions in 2023 [2]. Based on statistics, reasons of choosing to be vegan may because of their religion, ethics, economics and the environmental concerns [3]. These includes avoid having animal origin food to protect animals, or reasoned by that animal farming can cause environmental damage. What else, some religious doctrines, like Buddhism, discourage the consumption of meat and fish. The importance of gut microbiota is gradually found and some even called it as "another organ" in the digestive system. It has been a hot topic in the nutrition area with the discovering that the gut microbiota is associated with the type II diabetes, cardiovascular diseases and colorectal cancer [4]. Recent studies on gut microbiota includes improving the metabolic syndrome (MetS), anti-cancer, especially the colorectal cancer [5]. There are also investigations finding out the dietary patterns could affect the gut microbiota environment [6]. With the characteristic of vegan diet, people living in long-term vegan life have more diverse and beneficial gut microbiota comparing to omnivores [7]. It needs to mention in this review, the short-term vegan diet represents individuals having vegan diet from 3 days to 2 weeks, and over 3 years for the long-term vegan diet. What else, high fiber and low-fat diet make vegans are able to secrete more serum bile juice to help digest lipid, without increasing fecal bile juice that may leading the damage of epithelial colon cells, since they may cause the gut inflammations or the colorectal cancer [4].

Although there have been many reviews comparing vegan diets with vegetarian diets, omnivorous diets, and western diets, as well as comparing the gut microbiota or BMI of short- and long-term vegans. There have been few works doing the conclusions of vegan diets in terms of their application to gut microbiota. This review uses PubMed as a search tool and aims to analyze the effects of a vegan diet on gut microbiota and the applications.

2. Gut Microbiota

A healthy human body requires the combined action of both internal and external systems. The gut microbiota works as the microbial barrier of body defense . It can defense the bacterial invasion, against the foreign antigen, loss of nutrients, supporting by the probiotics such as Streptococcus thermophilus, Lactobacillus acidophilus, and Escherichia coli [8]. The microbiota inside human body can be affected by the outside environment like pH or temperature, also the diet and life style people live [8]. The human gut microbiota consists of primarily bacteria, archaea, and microscopic eukaryotic organisms, along

with viruses, fungi, and protozoa [9]. The most studied and dominant microflora species founded are asporogenous gram-positive and gram-negative saccharolytic anaerobes, like Bifidobacterium, Lactobacillus, Propionibacterium, Bacteroides [10]. In which Bifidobacteria and Bacteroides make 85–98 % of intestinal microflora [10]. Among these bacteria, the genus Bacteroides, Prevotella, Bifidobacterium, Eubacterium, Clostridium, Streptococcus, and Enterobacteriaceae appear most in the fecal sample. Nevertheless, it needs to mention that some anerobic bacteria may hide in the gut mouscus making it hard to detect [11]. Therefore, using the fecal sample may be led the result to be biased.

3. Vgan Diet's Impact on the Gut Microbiota

Using metagenomic shotgun sequencing (MSS) to compare the gut microbiota of omnivores, pescatarians, vegetarians, and vegans. It turns out few significant differences in the most common bacterial species present. The most abundant species across all groups belong to the order Clostridiales and the genera Faecalibacterium, Bacteroides, Clostridium, and Prevotella [12]. However, vegans typically have a greater abundance of Bacteroidetes and a lower abundance of Firmicutes, contributing to a healthier gut environment.The shifting in microbiota composition are associated with reduced inflammation and improved gut health [13].Showing the correlation between gut microbiota and inflammatory diseases like obesity, vegans generally exhibit lower BMI and body weight. This also providing that the vegan diet may provide protection against obesity and related metabolic disorders.

3.1 The Beneficial of Vegan Diet

The beneficial of vegan diet can be seen in gut health, body weight, body fat, and lifestyle habits. In the area of gastrointrestinal health, like mentioned above, the high fiber consumption can help improve the insulin resistance. Indicated by the standadized mean difference of the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) as 1.64 [13]. In terms of body circumference, a vegetarian diet can be a prayer for weight loss among both healthy and obese vegans. In the 16 week low fat vegan diet randomized clinical trial (n=168), the vegan diet also has the ability of improve insulin sensitivity and decrease visceral fat [14]. improve beta-cell function in overweight individuals, aiding in better glucose regulation and reduced risks of type 2 diabetes [14]. The reason that can help with weight loss is that the vegan diet is a low calorie, high fiber diet. The fiber can also provide the play a full feeling, which is easier to accept for people who lose weight.

3.2 Time Effects on Vegan Diet

Although much research shows the vegan diet can provide a much diverse gut microbiota, this result is more common for the long-term vegan. For the short-term vegan diet, the result is still dispute. It needs to mention that the time range of short-term vegan diet are various, yet they are usually between three days to two weeks. According to the review study published in Frontiers in Nutrition, the short-term vegan diet lower the abundance of gut microbial diversity($p<0.0001$), with the hypothesis that a sudden change in the diet may stress the gut system [11]. Hence, causing the drop of abundance. Nevertheless, the drop of gut microbial diversity is together with the increase of Enterobacteriaceae with the reason explained above [11]. The short-term vegetarian diet allows the digestive system to adopt the shift in nutrients from animal source to plant based. Therefore, the bacteria species relate to the meat-rich diet may be limited, such as the bile- tolerant Alistipes [12]. Providing with an opposite opinion, there are also paper considered that short-term vegan diet could bring significant and temperate changes but with smaller changes comparing to the over three months vegan diet [15].

The long-term vegan diet has more positive impact for the gut environment. The long-term vegans are usually defined as being vegans over three years. As exemplified by increasing the diversity and function of the gut microbiota, showing as the increase of beneficial bacteria and the decreasing of pathogenic bacteria [3]. Long-term vegans have more proportions of Bacteroidetes, and a lower abundance of Firmicutes. The high fiber and polyphenols can help increase the bifidobacterium and lactobacillus, to therefore increase the fecal short chain fatty acids [15]. The fecal short chain fatty acids may increase the propionate and butyrate, causing the irritable bowel syndrome [16]. This improves inflammation in the body, along with the effects on weight management and type II diabetes [15].

3.3 Comparing Vegan Diet and Omnivores Diet

There are different results between gut microbiota from omnivores and vegans. Some study shows that, no taxa have significant differences in terms of the presence or abundance ($p=0.53$) at the genus level [17]. What's more, it was found that the abundance of Firmicutes in omnivores are 6% higher than those in vegans [18]. Actinobacteria and Verrucomicrobia is 2.4% and 0.2% high in omnivores than vegans respectively [18]. Nevertheless, in healthy vegan subjects with high carbohydrate intake, the indigestible carbohydrate diet increases the Bifidobacterium spp. and Lactobacillus spp. What else,the resistant

starch increases the lactic acid bacteria like Ruminococcus spp., Eubacterium rectale, and Roseburia spp [3]. They also showed omnivores' gut microbial are easier being affected than vegans because the lower fiber intake cause more second bile acids [3]. Another report observed that omnivorous diet have higher Enterobacteriaceae abundance comparing to vegan diet, with the high fiber diet helps lower colonic pH to prevent the pathogenic bacteria (like Enterobacteriaceae) to grow [11]. What's more, vegans also have lower abundance of ruminococcus torques, streptococcus thermophilus, Clostridium sp. and Clostridium saccharoyticum comparing to omnivores [19]. Some studies show the ruminococcus torques may degrade the mucus of intestine, bringing gastrointestinal disturbance [20].

4. A Vegan Diet Provides Additional Benefits by Regulating the Gut Microbiota

4.1 Weight Loss

In a study with 36 omnivores and 36 vegans in 2017. After within the same age range and trying more than one year's diet pattern, vegan group had BMI lower than 30 kg/m^2 [4]. In the research, it was found the average body weight fo vegans (70.1kg) was lower than the average weight of omnivores 73.6 kg [21]. Their BMI was behaved in the same pattern [8]. In another study, with the comparison of omnivores, the Mediterranean diet group's weight change is 0.17 kg, while the vegan diet group has the change of −1.05 kg (P=0.04) [21]. Illustrating the benefits of using vegan diet as a strategy for weight loss. This is also supported by that the vegetarian diet or vegan diet was more acceptable and satisfying [13]. What's more, vegan diet improved the HOMA-IR (standard mean difference: SMD = 1.64), total cholesterol (SMD= 2.51), HDL- cholesterol (SMD = 1.55), and LDL- cholesterol (SMD = 2.50), except for Triglycerides [13].

4.2 Apply of Vegan Diet to the Steatohepatitis Individuals

In using the fecal microbiota transplantation to treat the obese individuals with steatohepatitis, four healthy lean vegan donors' fecal was applied on ten individuals for three times within 8-week intervals. Eleven individuals used their own fecal microbiota transplantation as the treatment. Their result showed that using allogenic FMT, which was the lean vegan fecal can help increase the abundance of gut microbiota. Including Ruminococcus, Eubacterium hallii, Faecalibacterium, and Prevotella copri. Nevertheless, differences were not found in duodenal microbiota diversity and composition before and after 24 weeks in either FMT group. As a result, the NAS score (3.0 to 2.8) and steatosis (34.1to 36.5) have no significant impact, but after using the lean vegan fecal to do the FMT, the necro-inflammation scores and the ARHGAP 18 expression was also improved. Meaning the lobular inflammation and hepatocellular ballooning, along with the maintaining of endothelial cell alignment can be favorably impacted [22].

4.3 Vegan Diet may Treat Undernutrition Children with Microbiota-directed Complementary Food (MDCF-2)

In the work of using microbiota to direct complementary food intervention in 12 to 18 months old undernutrition Bangladeshi children for three months, it was found that children using microbiota-directed complementary food (MDCF-2) method was more effective than the standard ready to use supplementary food (RUSF) . What else, the beneficial bacteria like Agathobacter faecis, Blautia massiliensis, Lachnospira and Dialister showed an increase abundance, especially the Prevotella copri bacteria like Bg0018 and Bg 0019. Those bacteria have more unique PULs, helping to metabolite the sugar in MDCF-2. It can be said that the improvement of body weight was caused by the presence of prevotella [23]. The MDCF -2 included food with 'microbiota-active' ingredients. Such as chickpea, soy flour, peanut paste and green banana. Along with vegetable oil, sugar and micronutrients. The food complies with the vegan diet. It shows another possibility for the future apply of vegan diet. However, due to the low-calorie nature of the vegetarian diet, applying it to undernutrition groups is still uncertain.

4.4 Lowering the Cardiovascular Diseases Possibilities

A study (n= 3096) demonstrated that both short-term (3 days to 2 weeks) and long-term (over 3 years) plant-based diets are significantly associated with gut microbiota, which in turn influences cardiometabolic risk biomarkers such as fasting insulin, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total triglycerides (TG), and high-sensitivity C-reactive protein (CRP). Notably, the study highlighted that a long-term vegan diet lowers the abundance of Peptostreptococcus, a bacterium linked to inflammation [15]. This reduction is associated with lower CRP levels and improved HDL-C levels, suggesting a potential reduction in cardiovascular risk.

Moreover, the study found that the long-term plant-based diet is associated with greater microbial beta diversity, whereas short-term healthy plant-based diets are linked with increased microbial alpha diversity. The long-term

vegan diet may also reduce the presence of certain pro-inflammatory bacteria, such as those in the Actinomycetaceae family, which are abundant in individuals with chronic bacterial infections and asthma [15]. These findings indicate that a long-term plant-based dietary pattern may inhibit pro-inflammatory bacterial activity, thereby offering protective effects against cardiovascular diseases by improving cardiometabolic health.

5. Limitation

Many reports and reviews found that the vegan diet can help with the insulin regulation. However, there was no follow-up on these points. The vegan diet has also been used in the previous article to help reduce weight and improve BMI, but unfortunately there is very little information on how these applications have been interpreted in terms of gut microbiota. What's more, short term and long-term vegan diet have variance consequence, yet the specific time range of these term are not well explained.

In the above data survey, it is interesting to note that not only was long-term vegan diet associated with more beneficial gut microbiota, but also vegans tend to live in a healthier lifestyle. This may be because vegans, in addition to choosing a vegan diet for ethical reasons, also have health concerns, and thus tend to live in a healthier lifestyle than others. These variables may also lead to changes in the study of the gut flora of vegetarians, which may be a variable in the collection of experimental data. What else, the term plant based food is sometimes confused with vegan diet. There are many articles where the term plant based food is used in the context of vegan food. At the same time, there are articles showing that the cholesterol content of these two diets is different, which means that there should be a substantial difference between the two diets in terms of nutrients.

However, the inappropriateness of vegan diet for gut microbiota has not been clearly found. And there are almost no articles that explain in detail the specific ratio of protein, fat, and carbohydrates for vegan diet to improve intestinal flora. The repeat success rate of subsequent treatment is not high. To address these limitations, future studies can further explore the impact of a vegan diet on gut microbiota and the potential for broadening its application.

6. Conclusion

The review described the correlation of vegan diet and gut microbiota, illustrates the benefits of vegan diet. Along with showing the time effect of vegan diet can lead to differences on gut microbiota, and the imply of vegan diet. This includes the treating of steatohepatitis, undernutrition children, obesity people, and cardiovascular disease patients. Finding the possibilities of using vegan diet's to do the modification on the gut microbiota, furthering apply them into the clinics. For example, the fecal microbiota transplantation treatment, or and microbiota-directed complementary food treatment. In conjunction with using vegan diet as a kind of diet to improve the obesity. Nevertheless, there are still limitations like the uncertainty of timing, and the unclarity of each food proportions of vegan diet. In the future, new treatment methods can be further studied in combination with the high abundance of beneficial gut microbiota contained with the vegan diet, exploring more possibilities.

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