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The Health Effects of a Plant-based Diet on the Human Gut Microbiome

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Abstract

The popularity of a plant-based diet is sweeping the western world. Markets and social media influencers are promoting and encouraging this dietary lifestyle. With people switching diets, research is needed to see how one's gut microbiome and health are affected. In this review article, the health effect of a plant-based diet on the gut microbiota is evaluate. Over 15 articles **contained** research on the physiology of the gastrointestinal system, microbes in the gut, nutrition, and diets affecting health issues. It is concluded that a plant-based diet promotes good health and gut microbiome; however, there are some nutritional deficiencies that may arise from a plant-based diet. For one to fully benefit from the health effects of a plant-based diet, supplements need to be taken consistently.

Introduction

Food is great way to bring people together. It's commonly enjoyed in social events. Many cultures have different styles of foods. Depending on the region of the world, will determine the popularity. In fact, in the western part of the world, there is a new diet gaining clout. Today's society is shifting into a plant-based diet; it is becoming popular throughout the states. Markets are catering to those that choose to have a restricted diet. There are endless options of meals and recipes to support one's dietary needs. Brands like Gardein, Lightlife and Quorn are plant-based brands flooding markets across the states. These plant-based diets are promoted on social media platforms by influencers and are said to be healthier. With the popularity of a plant-based diet rising, additional research is needed to evaluate the health effect on the human gut microbiome.

Background

Types of Diets

There are plenty of diets available for those who wish to change their eating habits. For simplicity, diets can range from, omnivore, vegan, and vegetarian. An omnivore diet consists of consuming both animals' products, meats, and plants. Vegans only consume plants for food. Individuals who are vegans have dietary restrictions. They avoid ingesting meat and using animal-based products. Veganism is an all-natural driven diet and lifestyle. The vegetarian diet consists of plant-based driven meals. Vegetarians do not consume meat. Unlike vegans, vegetarians are allowed to consume animal-based products such as dairy. Each diet has different beneficial value and provides nutrients.

Composition of the Gastrointestinal System

The gastrointestinal system is made up of the alimentary canal, stomach, accessory organs, small intestines, large intestines, and the anus. Accessory organs, digestive enzymes and microorganisms aid in enhancing the digestive process. In combination, these elements work together to supply the body with adequate nutrition. The digestive process begins in the mouth. It is composed of teeth, tongue, palate, and salivary glands. The bolus, a ball of saliva moistened food, is propelled from the upper gastrointestinal tract to the lower gastrointestinal tract via the alimentary canal. Next stop is the stomach in the digestive process.

The stomach is a very muscular and hollow organ in the digestive tract. It is composed of muscles, enzymes, and sphincters. There are three layers of muscles: an outer longitudinal layer, a middle muscular layer, and an inner oblique layer. They help with churning in the digestive process. Pepsinogen an enzyme in the stomach, is converted to the digestive enzyme pepsin via hydrochloric acid activity. Pepsin breaks down long chain proteins. During the digestive process

sphincters in the stomach acts as valves that contain and release digestive material from each part of the digestive tract. When digestion in the stomach ends, sphincters open and releases its contents into the small intestines.

The small intestine is composed of three parts: duodenum, jejunum and ileum.

Duodenum is the first part of the small intestine. It contains valves from the accessory organs: pancreas and gallbladder, that release enzymes that further digestion. Nutrients from the stomach is absorbed here. The jejunum is the middle part of the small intestines and furthers digest food. Following the jejunum, food is propelled to the last part of the small intestines called the ileum. Most water and nutrients are absorbed here. The ileum is the longest section of the small intestines and is connected to the large intestine.

There are four parts which composes the large intestines: cecum, colon, rectum, and anal canal. The colon is broken into three parts: ascending, transverse, and descending. Digested food moves through the cecum from the jejunum, ascending colon, transverse colon, descending colon, rectum, and anal canal. Water and waste, undigested food material and food broken down by bacteria in the large intestine, are stored in the rectum. The large intestines are the largest portion and end of the digestive system.

The Function of the Gastrointestinal System

Proper function of the Gastrointestinal system is essential to adequately supply the body with food. Nutrients are broken down into absorptive particles and used for cell repair, cellular maintenance, and energy. The important nutrients are carbohydrates, protein, fats, minerals, and water. Enzymes such as amylase, are released from the salivary glands and helps break down proteins before food reaches the stomach. In the stomach, digestive enzymes are released, and churning, and contraction of the stomach muscles helps mix digested components. The small and

large intestines hold enzymes and microbes that further the digestion process. Blood vessels help to distribute absorbed nutrients throughout the body.

Microbes Populating the Gastrointestinal System

The gastrointestinal system is composed of microscopic agents. These microbes can be classified into three domains: Archaea, Bacteria, and Eukarya, also viruses (Sakkas et. al, 2020). They play major roles in enhancing the digestive and metabolic activities. Over 100 trillion microorganism and over 100 bacterial species make up the normal flora of the human gastrointestinal system (Sakkas et. al, 2020). The normal flora are microorganisms that live in the intestines of an organism and does not cause a disease. Humans and the microbes have a symbiotic relationship. They both benefit from each other in the exchange of services. Bacteroidetes, Bifidobacterium, Firmicutes, Actinobacteria, Proteobacteria, Fusobacteria and Verrucomicrobia are the primary species of the gut normal flora (Sakkas et. al, 2020). Colonization of the gastrointestinal system occurs at birth. When a baby is delivered vaginally, microbes from the vagina colonize the gut and if delivered via cesarean, microbes on the surfaces of parents and hospital staff colonize the newborn's gut (Milani et. al, 2017). Microbes and humans depend on each other.

Nutrients

Plant-based foods contain great nutrients that can be beneficial to the human gut microbiota. Phytochemicals are not essentials nutrients but are chemicals produced by plants. They help plants fight against bacteria, viruses and being eaten by insets and animals. When consumed by humans, phytochemicals can be modified by microbiota affecting their bioavailability and bioactivity (Norman and Klaus, 2020). Ultimately phytochemicals are reported to have a huge effect on health (Craig, 2009).

There are more nutritional value of a plant-based diet. Fiber is a carbohydrate that cannot be broken down by human digestive enzymes. It's found mostly in the fruits and vegetables that we eat. Fiber plays a huge role in the digestive process and decreases the chances of constipation. It regulates smooth defecation. Folic acid is vitamin known as B-9. It's helpful in red blood cell formation and cell growth and function (Neufinger and Eilander, 2021). Beans, nuts, peas, and dark green leafy vegetables contain folic acid. These are just a few foods on how this nutrient can be obtained.

Vitamin C is water soluble vitamin found in citrus fruits and vegetables. It plays an essential role in growth, development and body tissue repair. Vitamin C is a vital component of nutrients. Vitamin E is a fat-soluble vitamin. It is found in fruits, vegetables, nuts and seeds. Vitamin E is important for brain, skin, vision and reproduction health.

Potassium is essential mineral in the body needed by all tissues. It is found in bananas, spinach, sweet potatoes, and many more fruits and vegetables. The main function of potassium is to help maintain fluid levels in the body. It regulates the sodium potassium pump and helps with muscle function. In addition, magnesium is an essential mineral that regulates muscle and nerve function. Also, it supports the immune system and regulate heartbeats.

Antioxidants are found mostly in fruits. They protect cells from oxidative damage and free radicals (Craig, 2009). Free radicals are independent molecules that have unpaired electron in their atomic orbital. The instability of the atom can cause cell damage and illness. Vitamin B6 keeps the nervous and immune system healthy. It can be found in salmon, tuna, liver, chickpeas and poultry. These amazing nutrients are consumed through varies food.

Vitamin B1 is also known as thiamin. Kale, asparagus, cauliflower, oranges, potatoes, and many other fruit and vegetables contains this vitamin. The main function of vitamin B1 is to

regulated energy in the body. It plays a role in the metabolism of glucose and in the function of nerve, muscle and heart. Calcium is another essential nutrient consumed through food. It is a mineral that is commonly known to promote health teeth and bones. However, calcium also plays a role in blood clotting and regulating muscle contraction. Dairy products, soybeans, dark green leafy vegetables, and beans are known to have high concentration of calcium.

Iron is a mineral in the body that have many roles in physiology. It's in hemoglobin in red blood cells. Iron helps with carrying oxygen throughout the body from the lungs. Dark chocolate, white beans, meats, soybeans spinach and shellfish contain high levels of iron. There are many more nutrients that are essential for the human body. Every nutrient is essential and play a role in how the body functions.

Nutrients are a key part of optimum human physiology. They are substances obtained through the consumption of food. Depending on what diet you have, the quality and quantity of nutrients may differ. A plant-based diet is rich in phytochemicals, fiber, folic acid, vitamin C, vitamin E, potassium, magnesium, and unsaturated fat (Winston, 2009). These nutrients impact different biological mechanisms and metabolic processes. Fruits and vegetables are rich in fiber, folic acid, antioxidants, and phytochemicals (Winston, 2009). In addition, vitamin B6, vitamin B1, calcium, iron are reported to be high in a plant-based diet (Neufingeri and Elliande, 2021). Knowledge on the nutritional value of a diet can help guide in making the best dietary choices. Dieting appropriately can be the key to good health.

The Health Effects of a Plant-Based Diet

There are some great advantages to one's health by having a plant-based diet. Plant-based food is very rich in essential nutrients for optimal human physiology. According to a research

article “Possible Biochemical Processes Underlying the Possible Effects of Plant-Based Diets”, plant-based diets have a positive physiological effect on different aspects of health (Szabo et. al, 2021). The plant-based food is rich in antioxidants and phytochemicals. These nutrients can protect the body from cell damage and illness. Diets containing animal flesh and meat products are said to trigger immune responses and chronic inflammation in the human body (Szabo et. al, 2021). High levels of milk and meat consumption are associated with elevated IGF-1 levels, which may increase risks of prostate cancer in men (Szabo et. al, 2021). IGF-1 is a hormone produced by the liver and some tissues. Its main job is to manage the effects of growth hormone in the body (McCarty, 1999). According to the research article, “GCN2 and FGF2 are Likely Mediators of the Protection from Cancer, Autoimmunity, Obesity and Diabetes Afforded by Vegan Diets”, essential amino acids in vegan’s diets may lower IGF-1 levels (McCarty, 2014). Lower levels of IGF-1 can decrease the risk of developing prostate cancer in men. Monitoring what you eat can definitely go a long way.

A good healthy plant-based diet promotes healthy microbiota which can impact general health. According to a research article, “Veganism, aging and longevity: new insight into old concepts”, vegetarians and vegans have more diverse gut microbiota than omnivores (Norman and Klaus, 2020). This is beneficial for health. A vegetarian diet is associated with high levels of bacteria that produces SCFA (Barret et. al, 2018). SCFA stands for short chain fatty acids and it’s believed to promote a healthier gut mucosa and lower levels of inflammation (Barret et. al, 2018). Humans and the microbes in the gastrointestinal system have a symbiotic relationship. They both benefit from cohabiting together. According to the article, “Nutritional Status and the Influence of the Vegan Diet on the Gut Microbiota and Human Health”, increase of both Bifidobacterium species and Lactobacillus species provides cardiovascular protection and

antibacterial and anti-inflammatory effects (Sakkas et al., 2020). There are more benefits of a plant-based diet and its effects on human health.

Omnivore diets are known to have high protein intake due to the consumption of meat. Mass protein consumption may have some antagonist effects by altering the mTOR activity (McCarty, 2017). Mammalian target of rapamycin (mTOR) is a protein kinase that plays a role in the synthesis of cell growth (Szabo, 2021). According to the article, “Possible Biochemical Processes Underlying Positive Health Effects of Plant-Based Diets”, leucine is a strong important signal for mTORC1 activation (Szabo, 2021). Leucine is an essential amino acid. Foods high in leucine are meats and dairy products. Decreasing the intake of leucine reduces the activity of mTORC1 signaling pathway which can prevent type II diabetes, obesity and cancer (Szabo, 2021). By adopting a plant-based diet, one can have a healthier life.

A healthy gastrointestinal system is essential for optimal function. Microbes in the gut help to metabolize nutrients. According to the research article, “The Influence of Animal or Plant-Based Diets on Blood and Urine Trimethylamine-N-Oxide (TMAO) Levels in Humans”, diet has a strong influence on TMAO levels (Lombardo et al., 2022). TMAO is a metabolite made by the microbes in the gut from metabolizing choline, betaine and L-carnitine (Lombardo, 2022). Consumption of red meats increases TMAO and is associated with an increased risk of cardiovascular and neurological disorders (Norman and Klaus, 2020). Studies have shown that a diet rich in fiber from vegetables, fruits and legumes can reduce the metabolism of TMAO via microflora by 40 % (Lombardo et al., 2022). Microbes in the gut deserve a lot of respect.

Type II diabetes is plaguing the western world. It occurs when the body becomes resistant to insulin. This causes glucose to accumulate in the blood and cause damage to different organs like the kidneys. However, a Danish study of 277 non-diabetic individuals were followed and

found that the gut microbiota contributes to insulin resistance (Clark et al, 2017). Discovering this may develop new target therapies for people with type II diabetes. A healthy plant-based diet lowers the risk of type-2 diabetes and cardiovascular diseases (Norman and Klaus, 2020). The key to preventing and managing inflammatory diseases such as diabetes may be solved by dieting. According to the research article, “Impact of Protein Intake in Older Adults with Sarcopenia and Obesity: A Gut Microbiome Perspective”, an abundance of Firmicutes is seen in the microbiome of obese and insulin resistant people (Prokopidis et al, 2020). Manipulating the Firmicutes population in the gut may help in treating insulin resistant patients. Bifidobacterium which is one of the major species in the microbiota, decreases with age (Sakkas et al, 2020). A decrease in Bifidobacterium is directly related to an elevated level of circulating lipopolysaccharide (LPS) (Prokopidis et al, 2020). LPS is a marker of endotoxemia which is directly related to obese and diabetic people (Prokopidis et al, 2020). Promoting the population of the good microbe species in our gut can greatly impact our health long-term.

Estimated glomerular filtration rate (eGFR) are a measure of how well the kidneys are working at filtering waste and water from blood. High eGFR levels means the kidneys are not working at optimal level and cause damage to other organs. According to the article, “Plant-based Diets and Incident CKD and Kidney Function”, plant-rich diets lower the risk of chronic kidney disease (Kim et al, 2019). The healthy consumption of healthy plants is associated with a CKD lower risk and slower eGFR decline (Kim et al, 2019). The correlation between dieting and health is becoming more apparent.

Nutritional Gains from a Plant-based Diet

Eating is a part of sustaining life. Breakfast, lunch, and dinner are the general eating times people consume food. Also, some may have snacks in between. Food contains

macronutrients and micronutrients that aid in optimal human physiology. The quality and quantity of nutrients obtained are limited to one's diet. According to a research article, "Nutrient Intake and Status In Adults Consuming Plant-Based Diets Compared to Meat-Eaters", vegetarians and vegans are at risk for vitamin B12, D, iron, zinc and calcium deficiency (Neufingerl and Eliander, 2021). Having low levels of these micronutrients can affect one's health. Taking supplements while on these plant-based diet may lower the chances of becoming malnourished. However, there are some nutrients that can be found in higher concentrations within a plant-based diet compared to meat eaters diet.

Fiber is a nutrient that aids in regulating bowel movement. It's high in grains, fruits and vegetables. 35 studies showed that average fiber intake was 44g/d in vegans, 28 g/d in vegetarians and 21 g/d in meat-eaters (Neufingerl and Eilander, 2021). Vegans are shown to have higher fiber intake compared to the other dietary groups. Vegans also were shown have higher polyunsaturated fatty acids (PUFA). A study showed PUFA was 8.84%E in vegans, 5.95%E in meat-eaters, semi-vegetarians 7.67% E and vegetarians (Neufingerl and Eilander, 2021). PUFA is a healthy fat. It is important for nerve function, blood clotting and brain health. Vegan's diets are also have a high intake in vitamin B1, vitamin B6, folate, vitamin C, magnesium and vitamin E (Neufingerl and Eilander, 2021). Each nutrient is vital.

Depending on what we eat will determine what population of microbes inhabits our gastrointestinal system. Vegans and vegetarians have a very diverse and stable gut microbiota compared to people on animal-based diets (Norman and Klaus, 2020). Vitamins such as B12, folate, vitamin K, nicotinic acid, and pyridoxine and bile acids are synthesized by the gut microbiome (Rowland et al, 2018). Among these vitamins, vitamin K plays a key role in the coagulation process. It is administered to newborns after delivery because their gut is colonized

with the microbes that cannot synthesize vitamin K yet. Values of having microbes that synthesize nutrients is dependent on the consumption of plant-based meals. Proteins are correlated with a great abundance of Bifidobacterium, Roseburia, Ruminococcus bromii, Lactobacillus and Roseburia (Prokopiadis et al, 2020). Humans gain nutrients through consuming food and by the synthesis of vitamins from microbes in the gut.

Conclusion

The popularity of a plant-based diet has proven to have some effect on the gut microbiome and human health. There are some great nutritional values to have a rich plant-based diet. Compared to meat-eater's diet, people with plant-based diets were shown to have much higher index of macro and micronutrients. Studies show that diets can have some effect on one's health. Although, a plant-based diet is very nutritious, there is a downside to having a plant-based diet, the difference in the intake of zinc, protein and other nutrients. In order to effectively benefit from the value of a plant-based diet, one should take dietary supplements daily. This will help avoid becoming deficient in specific nutrients prominent in animal-based products vs plant-based diets. Going forward there needs to be more studies on the health effect of a plant-based diet on the human gut microbiome to encourage alternative treatment for inflammatory diseases. In this review, we discussed the benefits and pitfalls of a plant-based diet on gut microbiome, however more studies is needed to better understand diet and how it affects health.

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