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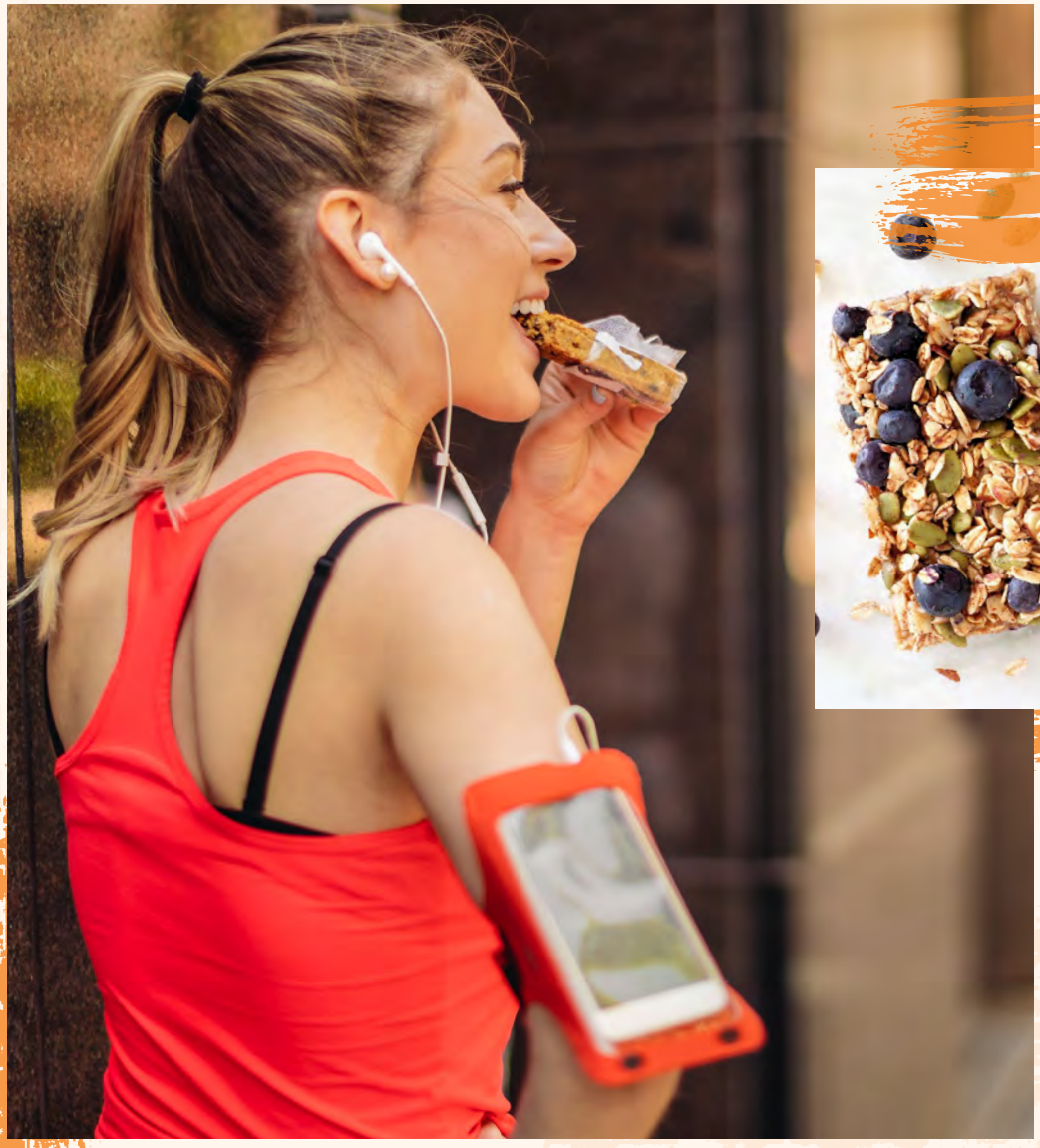

Digestive Health 101

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ABSTRACT

Our digestive system breaks down complex foods in order to absorb their constituent nutrients, which then are assimilated and utilized for wear and tear, energy generation and body functioning. Digestion of food translates into health, and the health into various dimensions of human happiness and wellness. There are certain common ailments relating to the digestive system that affect digestion and subsequently digestive health. However, these can be modulated to a certain extent by diet-based strategies. Other prevailing factors include lifestyles, life stage (e.g., age), life state (e.g., pregnancy, lactation), genetic variations, diseases, and environment.

Digestive health is the very basis of human consciousness and overall health.

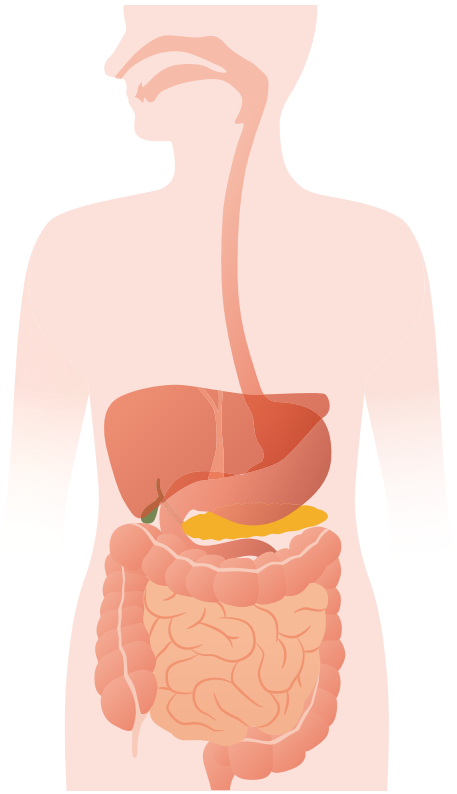
Gut microbiota, which is at the center of digestive health, is an important factor in the maintenance of overall health and diseases. Diet-microbiota interactions is an expanding area with significant therapeutic potential.

INTRODUCTION

Human growth pattern, health status, energy level, productivity, creativity, and even emotions and psychology are all determined primarily by the digestion of consumed foods. Health is the very basis of all human activities and digestion is the very essence of the health. It is not food as such, but the digestion of a given food that imparts health and sets out all outputs of a human individual. A healthy digestive system ensures availability and assimilation of nutrients that kickstart several physiological processes within the body. Digestive related disorders range from acute to chronic and affect millions of people worldwide. Gastrointestinal (GI) and liver diseases alone are a growing health problems and result in more than 8 million deaths per year worldwide (Milivojevic and Milosavljevic, 2020). Major diseases directly affecting the digestive system are gastroesophageal reflux disease (GERD), *Helicobactor pylori* infection, peptic ulcers, inflammatory bowel disease (IBD), liver diseases, coeliac disease, and other functional GI disorders (Milivojevic and Milosavljevic, 2020). The World Gastroenterology Organization celebrates May 29th every year as “World Digestive Health Day,” with a mission to draw attention to the critical function and significance of digestive health.

MAJOR FACTORS INFLUENCING DIGESTIVE HEALTH

Digestion is a physiological process affected by several factors, for example, the sources of food, the nutrient composition of foods, lifestyle, physiology of individuals as affected by certain diseases, genetic factors, environmental factors, etc. Diet has the most impact on the capacity of the intestine to absorb nutrients. However, not all people absorb essential nutrients through digestion in the same way. Some genetic variations might cause physiological hindrances. Lactose intolerance and phenylketonuria (PKU) are two such examples. Lactose intolerance is primarily linked to single-nucleotide polymorphism (SNPs) affecting the minichromosome maintenance gene (MCM6 gene) that controls the lactase (LCT) gene (Enattah et al, 2002; Mattar et al, 2012). PKU occurs due to a genetic disorder leading to lack of phenylalanine hydroxylase, the enzyme responsible for the breakdown of phenylalanine in food. Building of phenylalanine in the blood can cause brain damage and excessive accumulation in pregnancy may cause possible developmental delay in babies (Matthews 2021). Nutrigenetics is an exciting area of scientific research embracing huge promises for nutritional recommendations for the people affected by nutrient digestion/ absorption related genetic disorders. Other factors affecting digestive health are listed in Figure 1. Changes in lifestyle (e.g., proper rest, sleep, exercise) and environment can affect homeostasis, causing disturbances in the gut which can affect digestive health negatively.



Diet & Lifestyles

- Sources of foods
- Food habits (e.g., vegan)
- Dietary composition
- Food quantity/portion
- Alcohol and drug consumption
- Food restrictions
- Microbial diversity and composition

Life Stage, State & Genetic Factors

- Age
- Ethnicity
- Life-state (e.g., pregnancy)
- Effect on protein (enzyme) synthesis
- Pathogenesis
- Microbial diversity and composition
- Allergenicity

Diseases & Environment

- Infection
- Altered gut microbiota
- Weather/climate
- Hygiene
- Soil-water-atmosphere quality/ environmental pollution

FIGURE 1: FACTORS INFLUENCING DIGESTIVE HEALTH

The human digestive system is an intricate collection of various organs. The largest structure of a digestive system is the gastrointestinal tract (GI). Gut health is a term increasingly used in the food and medical world. Used synonymously with digestive health here, it covers multiple aspects of the GI tract including the ones beyond digestion. A lot of organs coordinate and work together with the GI tract to digest and absorb nutrients. The important connection between the gut and the brain is an area of increasing recognition and assessment in the health community. The central nervous system (CNS) and the enteric nervous system (ENS) also coordinate and control digestive activity (Furness, 2012). Several gastrointestinal disorders can lead to neurologic disorders and vice versa. The field of neurogastroenterology covers the neurology of the gastrointestinal tract, liver, gallbladder and pancreas and encompasses control of digestion through the ENS, CNS, and integrative centers in sympathetic ganglia (Furness, 2012).

The GI tract is also involved in maintaining immune homeostatis. The gastro-intestinal associated lymphoid tissue (GALT) can discriminate between harmful and harmless antigens (Mason et al, 2008). Furthermore, a link between cardiac and gastrointestinal disorders are has been documented as they often share similar risk factors and symptoms (Gesualdo et al, 2016).

THE MICROBIAL ECOSYSTEM

The human intestines are populated by complex microbial communities called gut microbiota. This complex microbial ecosystem is made up of 100 trillion microorganisms that include bacteria, archaea, viruses, fungi, and eukaryotes. There are several animal and human studies that report the key role of gut microbiota in overall health.

The modification in the microbial ecosystem, or the microbiome, can alter digestion, metabolism, and immune responses (Gomaa, 2020). The altered state of gut is referred to as dysbiosis. The dysbiotic microbiota has been implicated in a range of diseases and not just limited to digestive health. These include inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), and wider systemic manifestations of diseases such as obesity, type 2 diabetes, and atopy (Bull et al, 2014).

Gut microbes are capable of producing a vast range of metabolites that are dependent on many factors, including nutrient availability and the gut environment, particularly pH (Conlon and Bird, 2015). Fermentation of non-digestive substrates like fibers (prebiotics in particular) is required for the production of gut metabolites. Competition for substrates between the microbes has a significant influence on which products are generated (Conlon and Bird, 2015). These metabolites deliver significant health benefits to the host. Some of the major metabolites produced from this fermentation include short chain fatty acids (SCFA) which act as key sources of energy for the body and promote cellular mechanisms. Majority of the proposed health effects, of the addition of probiotics, prebiotics, or synbiotics bank on the subsequent production of SCFAs (Wegh et al, 2019). SCFAs impact several other biological functions including immunity and inflammation. The major SCFAs produced are acetate, butyrate, and propionate (Conlon and Bird, 2015; Valdez 2018). Acetate is the most abundant SCFA and an essential metabolite for the growth of healthy bacteria in the gut. It is known to play a role in appetite regulation and cholesterol metabolism (Frost et al, 2014). Butyrate has an important role in glucose and energy homesostatis. It is also the main energy source for human colon epithelial cells (De Vadder , 2014). Propionate regulates gluconeogenesis and satiety (De-Vadder, 2014). Higher production of SCFAs correlates with lower diet-induced obesity and reduced insulin resistance (Lin et al, 2012, Zhao et al, 2018). These acids also help lower the pH within the colon, which inhibits the growth and activity of harmful pathogens (Conlon and Bird, 2015).

EXPLORING DIGESTIVE HEALTH INGREDIENTS
HARNESSING THE POWER OF DIETARY FIBER AND PREBIOTICS

Digestive health can be, to a larger extent, modified through food. Supplementation strategies include administration of probiotics, prebiotics, and postbiotics. Fiber is a key nutrient for a healthy microbiome. To date, there is no common global definition of dietary fibers (Guarino et al, 2020). The U.S. Food and Drug Administration divides fibers into: (1) Dietary fibers that consist of nondigestible carbohydrates and lignin, which are intrinsic and intact in plants; and (2) Functional fibers, which are isolated, non-digestible carbohydrates, with beneficial effects on humans (Slavin 2008). Apart from these definitions, fiber can also be classified as soluble or insoluble. Both soluble and insoluble fibers have beneficial health effects such as increasing fecal bulk, binding cholesterol, and fueling the gut microbiota. Prebiotic fiber is a soluble fiber that helps with the latter. However, the term prebiotic has evolved in recent years and includes ingredients beyond non-digestible fiber. These include certain carbohydrates, pectins, resistant starches, and even polyphenols (Martin et al 2012) that can have prebiotic effects on human body. Short-chain nondigestible carbohydrates like fructo-oligosaccharides (FOS), inulin type fructans, and galacto-oligosaccharides (GOS) are the characteristic prebiotics (Conlon and Bird, 2015) that stimulate the growth of primarily *bifidobacteria* but also *lactobacilli*, which are not the most abundant microorganisms in the intestine (Guarino et al, 2020). The positive health effects of dietary fiber are well established in scientific literature.

While the daily requirement for dietary fiber has been adopted by the WHO and other government and independent dietary associations, there is no consensus on the daily adequate intake of prebiotics.

The International Scientific Association for Probiotics and Prebiotics recommends an oral dose of 3 grams per day or more, with 5 grams being the target for FOS and GOS. Prebiotics have been shown to have both a direct and indirect effect on health. It helps improve bowel and immune function, supports metabolic health and increases calcium and magnesium bioavailability (Brownawell et al, 2012). There is mounting evidence that prebiotics modulate the immune system (by production of the SCFAs) and reduce the risk of inflammatory conditions, such as IBD, as well as functional bowel disorders like IBS (Brownawell et al, 2012; Conlon and Bird, 2015).

PROBIOTICS, SYNBIOTICS, AND POSTBIOTICS

Probiotics are widely known promising agents that are capable of beneficially modulating the intestinal ecosystem. The most available and consumed probiotics belong to the genus *Lactobacillus and Bifidobacterium*. Probiotics, although transient, may enhance the functionality of existing microbial communities in the gut (Hemarajata and Versalovic, 2013). They may also affect the composition and function of microbial communities by competing for nutrients and modulating of intestinal immunity (O'Toole and Cooney 2008). Probiotics have been extensively researched and have proven effective in the improvement of intestinal health, immune health, allergies, bowel diseases, and reduction of serum cholesterol (Kechagia et al 2013).

Synbiotics, initially referred to as a combination of probiotics and prebiotics that act synergistically, have been redefined by the ISAPP as, "a mixture, comprising live microorganisms and substrate(s) selectively utilized by host microorganisms, that confers a health benefit on the host." Synbiotics can prove to be powerful agents in modulating the composition and metabolic output of the gut microbiota.

Postbiotics are relatively new in the nutraceutical world. They can include many different constituents, including gut microbiota metabolites such as SCFAs, microbial cell fractions, functional proteins, extracellular polysaccharides (EPS), cell lysates, teichoic acid, peptidoglycan-derived muropeptides, and pili-type structures (Wegh et al, 2019). While human clinical studies evaluating postbiotics in the gut are scarce, it is a promising ingredient for the maintenance of overall health.

CONCLUSION

Digestive health plays a critical role in maintaining overall health and wellness. Diet and lifestyle can have significant impacts on human health and the gut microbiome also plays an important role in mediating these effects. Diet is one of the most effective management strategies for digestive diseases and other related disorders. Digestive problems are ubiquitous, so prebiotic based fortifications might appeal to a majority of the population. Probiotics and postbiotics, however, could be tailored to individual needs.

Human creativity and happiness are the attributes of digestive health within a healthy environment. All activities of life and all dimensions of human creativity depend on the state of health which is imparted by the foods processed through digestive system.

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