Gastrointestinal microbial ecology and its health benefits in Dogs

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Abstract

Gastrointestinal microbial balance is the most important prerequisite for normal functions of digestive system, physiological and immunological homeostasis in dogs as well as in other animals. It helps in prevention of pathogenic colonization, provides energy through SCFA by nutrient breakdown, and improves mineral-vitamin supply to host, augment host immune status. Hence, it is imperative to explore the potential means to improve the gastrointestinal microbial diversity which in turns boost up dog health.

Keywords: Gastro-intestinal microbes, Ecology, Dog, Nutrition, Health.

Introduction

The most divergent and metabolically active system of mammalian body is the gastrointestinal (GI) system also known as digestive system which undergoes various processes related to ingestion, digestion, metabolism and absorption of dietary nutrients. The digestive system involves many enzymes and hormones which help to provide energy to the host by utilization of nutrients, along with this there exists a well established symbiotic relationship between the host and microbes (bacteria, fungi, yeast etc.) that naturally inhabit the gut (Davis *et al.,* 1977). Large populations of micro-organisms inhabit the gastrointestinal tract of all animals and form a closely integrated ecological unit with the host. This complex, mixed, microbial culture can be considered the most metabolically adaptable and rapidly renewable organ of the body, which plays a vital role in the normal nutritional, physiological, immunological and protective functions of the host animal.

The microbial colonization is slow in newborn but it initiates immediately after birth. Age-related changes in the relative proportions of bacterial groups coincided with changes in diet and physiologic processes of the host and can influence nutritional state and disease resistance of developing dogs (Buddington, 2003).

The gut microflora faces daily challenges that can cause an imbalance between the so-called 'healthy' and pathogenic bacteria, for example poor diet, use of antibiotics, stress, unusual treats and food poisoning (Miles, 2007). For optimal functioning of GI tract 'balance' of the bacterial flora must be maintained, similarly, the direct effects of a change in dietary patterns and eating habits can affect overall gut functionality. In this backdrop the present review provides a glimpse on gastrointestinal microbial niche and its associated health benefits in dogs.

Gastrointestinal microbial diversity

As dogs are basically carnivores their lower tract is shorter in length compared to herbivores or omnivores. Besides many differences the gastrointestinal tract and their basic physiology resembles in dogs and human beings. Canines are devoid of the enzyme ptyalin (salivary amylase) in contrast humans do have. The pH of the digestive system varies from region to region with more acidic in stomach (pH-3) with becoming neutral to slightly alkaline (6-7.5) as progresses towards the distal portion of the GI tract but that of colon is 6.5 in turns the faecal pH lowers to 6 or less (Davis *et al.,* 1977). This low pH is due to production of acids because of bacterial fermentation in lower gut. In early age most abundant population are those of bifidobacteria, lactobacilli, bacteroides, facultative anaerobes as well as pathogenic clostridia and coliforms (Buddington, 2003). There is difference in adaptation of intestinal microbes from species to species. The bifidobacteria of canine origin cannot be identical with that of human origin. Some of the important bacterial species which resembles in human and dogs include those known as lactic acid bacteria lactobacilli and other microbes like bacteroides, clostridia, streptococci, coliforms and enterococci (Rinkinen *et al.,* 2004). Bifidobacteria are the major component of the microbial barrier to infection. Bifidobacteria produce a range of antimicrobial agents that are active against Gram-positive and -negative organisms (Gibson *et al.,* 1994).

The digestive tract includes three regions via. Stomach, small intestine and large intestine. Due gastric acidity the pH of stomach is lower hence only limited numbers of microbes can thrive in this region, approximately less than 1x104 cfu/ ml. As progress through GI tract digestive enzymes and juices make the pH nearly neutral facilitating growth of facultative as well as strictly anaerobes including *Streptococci, Lactobacilli, Enterobacteia bifidobacteria, Bacteroides* etc. The bacterial population in small intestine reaches up to 108 to 109 colony forming units (cfu)/ ml of the contents. Although small intestine has more number of microbes, colon is the profoundly populated with the bacteria, with a total population of 1011–1012 cfu/ml of contents (Cummings *et al.,* 1989).

In a study in which microorganisms cultivated from the beagle dogs observed that eighty-four species of bacteria representing 27 genera and five genera of fungi were isolated. The highest numbers (109 to 1010/g dry weight) of viable bacteria were from anaerobic genera (*Bacteroides, Bifidobacterium, Peptostreptococcus, Eubacterium, Clostridium*, and *Peptococcus*) and *microaerophilic* to anaerobic Lactobacillus species. The highest number of facultative anaerobes was almost always streptococci. (Davis *et al.,* 1977).

Health benefits of GI microbes

The intricate structure of the gastrointestinal villi and microvilli, it is possible to admit an abundant population of the microbiota which helps in many physiological, digestive, metabolic as well as immunological functions (Van Dijk, 1997). Proper nutrition and well established intestinal microbial balance is the mainstay of the good health and longevity of canine health. Any deviation from normal microbial equilibrium leads to variety of disturbances which includes indigestion, anorexia, diarrhea and malabsorption of nutrients (Berg,1996). The significance of the microbiota has been analyzed by comparisons of germ-free (sterile) and conventional animals, most often mice, rats, or chickens. Individuals grown in a microbe-free (sterile) environment lack many features of the immune system, require 30% more calories to maintain body mass and die sooner than those grown in normal conditions (Bäckhed *et al.,* 2004).

Bacteria indigenous to the gastrointestinal tract ferment dietary and endogenous carbohydrates into various volatile fatty acids (VFA) also known as short-chain fatty acids (SCFA) that provide energy for the gut epithelium and other tissues and facilitate the absorption of sodium and water. Current estimates are that VFA contribute approximately 70% to the caloric requirements of ruminants, such as sheep and cattle, approximately 10% for humans, and approximately 20-30% for several other omnivorous or herbivorous animals (Bergman, 1990). They also convert dietary and endogenous nitrogenous compounds into ammonia and microbial protein and synthesize B vitamins.

Gut microbial cells also synthesize B vitamins, which is mixture of ten different water soluble vitamins. The B-complex vitamins appear to be absorbed mainly from the small intestine by carrier-mediated, Na-dependent transport mechanisms. Wrong *et al.* (1981) concluded that there was good evidence that nicotinic acid, riboflavin, pantothenic acid, thiamin, biotin, pyridoxine, folic acid, and vitamin B12 are synthesized by microbes in the colon.

The resident microbiota of the canine gastrointestinal tract acts as a fundamental part of the host defense mechanism against pathogens. To be able to induce a disease, a pathogen must first colonize the intestinal mucosa but a large population of beneficial bacteria competitively excludes pathogens by occupying receptor sites and competing for space, nutrients, etc. (Gibson *et al.,* 1994). These micro floras help to prevent ill health that may arise due to invaders by preventing their colonization. (Tannock, 2001).

In addition to the immunopotentiation (maturation of the gut-associated lymphoid tissue, GALT) the commensal bacteria play a significant role in the nutrition by degrading otherwise non-digestible food compounds, conversion of urobilin to urobilinogen, conversion of cholesterol to coprostanol, and in absorption of ions. Indigenous bacteria also stimulate vascularisation and development of intestinal villi, have an important role in the metabolism of endogenous and exogenous compounds (detoxification), and in prevention of colonization and proliferation of pathogens and opportunistic microbes (Hooper *et al.,* 2002).

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