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Prebiotics and Probiotics: It's Impact on Host as Internal Healers

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Abstract

The regular or continuous use of antibiotics or chemotherapeutic agents to cure disease have led to problems of drug resistance towards various microorganism. The use of prebiotic and probiotic can solve this problem somehow due to their preventative and ecofriendly approaches, particularly in light of new trends toward organic production systems. Probiotics and Prebiotics deal with gastrointestinal lining and improve health benefits of human as well as animals. The components of these should be a part of our foods, or it may be including in our diet to increase health benefits at the nutritional and therapeutic levels. Prebiotics, being indigestible carbohydrates available in thousands of different plant foods, stimulate the beneficial probiotic microorganisms to grow and multiply and help to improve host intestinal probiotic balance. Probiotics are a diverse group of living organism having non-pathologic bacteria that are functionally beneficial for improving health due to their ability to prevent inflammation that takes place in intestine. Action mechanism of both these in relation to each other as well as their intestinal interactions has been discussed. The beneficial effects include disease treatment and prevention as well as improvement of digestion and absorption in the host. The alarming increase in inappropriate use of antibiotics and development of bacterial resistance makes prebiotic & probiotics a very interesting field for research. In the present scenario, both have shown a number of beneficial effects in a variety of disease related to gastrointestinal as well as non-gastrointestinal such as colon cancer, ulceration in intestine.

Keyword: prebiotic; probiotic; microorganisms; bacteria, health; animal; disease

Introduction

People awakening and awareness of their diet and health has enhanced the demand for quality food products that increase health benefit beyond the level of providing basic nutrition from regular diet. The main reason behind this awareness is the fact that whenever body's nearly perfect healthy micro-environment is disturbed and leads to path-physiological consequences, that may arise due to infection, weak immunity system, extra dose of medicine or poor development of the tissue etc. (De Simone et al., 1992; Link-Amster et al., 1994; Saavedra and Tschernia, 2002), there is always a need to attain normal status at the earliest possible. The latest concept of diet supplements with combinations of probiotics and prebiotics have also gained momentum as they help in keeping body fit by normalizing the healthy micro-environment. The micro-environment inside our body varies from place to place such as mouth, stomach, intestine, colon and this tract is ideally full of healthy microorganisms that not only thrive in a healthy ecosystem but are sometimes as beneficial to host as these are to them (Sihag and Sharma, 2012). Probiotics and prebiotics are quickly gaining popularity among scientific community being as a safe and effective agent that help to regulate the body's micro-environment. Selection of a suitable pre and probiotic is now-a-days a main concern as a wide range of these are available in market.

Probiotics and prebiotics do not simply stop doing an effective job of recolonizing the body's micro-environment but also monitor the colon. probiotics and prebiotics have observed to play an essential role in the treatment of metabolic disorders such as Type 2 diabetes (T2DM), Cardiovascular disease (CVD), and obesity etc (Yoo and kim, 2016). By using the supplements of these, the micro-environment of the host body can be enhanced and keep pathogenic bacteria away from attaining an unwelcome toehold on host body systems. The concept of symbiotic mechanism has been suggested to describe relation of colonic food with prebiotic and probiotic as health enhancing functional food. The advancement in Biotechnology with these as a health supplements need vaster detail about the function between enteric feeding and the microenvironment exist in it that play important role in host defense.

Prebiotic

Prebiotics are the component required for the growth of probiotic bacteria and help to colonize the bowels. These are the non-digestible food elements which trigger stimulate the activity of beneficial bacteria exist in the gastrointestinal tract of the host. The name prebiotic was given by Marcel Roberfroid in 1995 (Gibson and Roberfroid, 1995; Roberfroid, 2007). The exciting thing about prebiotics is that, while passing through our stomach and small intestines, these molecules clearly pass out from our digestive system due to unablity of digestive system to act upon its components and these are only accessible for probiotic bacteria to utilize as nutritional purpose for their own. Healthy bacteria with its Ideal nutrition build up a perfect environment inside the colon to colonize itself and swipe out the pathogenic bacteria. A small partion of prebiotics gets assimilated in the region of upper gastrointestinal tract. Prebiotic may perfom various function such as antimicrobial, anti-carcinogenic, anti-osteoporotic hypolipidemic, glucose-modulatory, mineral absorption and its balance.

A prebiotic is a basically fermented compound includes carbohydrates (such as oligosaccharides) as well as non-carbohydrates that permits specific changes in the microflora of gastrointestinal, both in its composition as well as its activity. The mostly used prebiotic include Fructooligosaccharide, Isomaltooligosaccharide (Grisdale-Helland et al., 2008), Xylooligosaccharide (Roberfroid, 1996; Ringø et al., 2010b; El-Dakar et al. ,2007; Burr et al., 2008, 2009; Hartung et al., 1997 and Lochmann *et al*. 2009), Inulin (Wang and Gibson, 1993; Ringø, 2004), Fibers (Eastwood and Kritchevsky, 2005), Oligomate, Palatinose, Pyrodextrin, Raftiline etc.

Prebiotics stimulate probiotic bacteria not only to grow but also to produce compounds advantageous to the host. Their colonic fermentation by bacterias like bifidobacterium, lactobacilli and some other certain bacteria in the colon that produce short chain fatty acids (SCFAs) like acetate, propionate and butyrate; the hydrogen gases, hydrogen sulphide, carbon dioxide, methane; acetate, pyruvate, succinate and formate which are the important factors to determine the pH of gastrointestinal tract (Campbell et al.,1997). The SCFA have strong influence on the metabolism of the host in order to colonic absorption of calcium and also magnesium ions. This can be useful in inhibiting osteoporosis and osteopenia. The increased concentration of calcium in the colon may assist to control the formation of insoluble bile or salts of fatty acids. As a result, the possible destructive influences of bile or fatty acids on colonocytes can be reduced. SCFA of non-digestible carbohydrates are fermented at much faster rate than long chain fatty acid (Macfarlane et al., 2006; Oufir et al., 1996 and Givson et al., 1996). Thus, the short chains are readily fermented in the proximal part of the colon whereas long chain fatty acid allow the stimulation of bacterial metabolism in a more distal part of the colon which is very much energetically depleted. Bacteria starve and the proteolysis of dead cells and the subsequent strictly anaerobic fermentation of the released amino acids result in production of cytotoxic putrefaction which release phenolic compounds like skatol, indole and resol. These compounds are very important for the prebiotic utilization.

Further, Prebiotics may encourage the growth of bifidobacteria and lactobacilli in the large intestines (Bertazzoni-Minelli et al., 1996). These bacteria are able to strengthen the barrier of the intestinal mucosa, assisting in suppressing the connection of pathogenic bacteria mainly by crowding them out (**Bhuiyan** et al., 2017; Thakur et al.,2018). Prebiotics can also increase antimicrobial materials and encourage antigen specific and non-specific immune responses. The prebiotics is believed to be able to reduce triglyceride extent due to the reduced hepatocyte *De Novo* synthesis of triglycerides. Further, they can reduce total cholesterol and LDL-cholesterol rates to some extent. The possible influence of the prebiotics on blood glucose can be explained in different ways; the oligosaccharides may postpone gastric emptying and /or decrease the transportation gap in small intestinal area. *In vitro* and animal-based studies indicated that these bacteria can be attach to and inactivate some carcinogens (Burns and Rowland, 2000). In addition, they are said to be capable of inhibiting the development of tumors and suppress the bacteria that are likely to convert precarcinogens into carcinogens. It is probably due to potential action of butyrate. Butyrate accompanied by other short-chain fatty acids are created by bacterial fermentation of different prebiotic oligosaccharides in the colon.

Probiotic and its selection criteria

Probiotic, the word originated from "pro" and "bios" (greek word) means life and this term was first described by Werner Kollath in 1953 (Gismondo et al., 1999; Hamilton-Miller et al. 2003). Further it is defined by Lilly and Stillwell (1965) as the substances produced by one bacterium that stimulated the growth of anothers. This definition was extended by Fuller (1989) in context of an agricultural perspective as a live microbial feed supplement which beneficially affects the host by improving its intestinal microbial balance and redefined by Gatesoupe (1999) on the perspective of aquaculture as microbial cells that are administered in such a way so as to enter the gastrointestinal tract and to be kept alive, with the aim of improving health. Irianto and Austin (2002) conclude the definition again as "a probiotic is an entire or components(s) of a microorganism that is beneficial to the health of the host".

In present scenario, probiotics are quite well known as a health promoting efficient foods that can be used as therapeutic, prophylactic and growth supplements for humans and animals along with aquatic animals due to increase its demand for ecofriendly aquaculture. The microbial community present in the gastrointestinal tract of fish and shellfish depends upon the external environment through which the water flow passing into its the digestive tract. Most bacterial cells are temporary exist in the gut of aquatic animal that influences by the continuous interruption of microbes coming from water and food (Fuller, 1989 and Gibson, 1997).

Probiotics are different strains of living bacteria which may be in their natural state or in their spore form, has the capability to have long shelf life and survives through the journey of the stomach that ends upon the colon begins. The living bacteria further multiply here and develop itself into health colonies of its own and adhere to the wall of the colon. In general, a 'probiotic' should be non-pathogenic and beneficially affect the host health; should withstand incorporation into a delivery vehicle at high cell counts, and should remain viable throughout the shelf-life of the product; should be accepted by the host, e.g. through ingestion and potential colonization and replication within the host. It should withstand transit through the gastrointestinal tract, that is, show acid and bile tolerance; should actually work *in vivo* as opposed to *in vitro* findings. Also should be able to adhere to cells of the intestinal epithelium and/or colonize the lumen of the tract (Guo et al., 2011; Bordoni et al., 2013). It should preferably not contain virulence resistance genes or antibiotic resistance genes and able to show antagonistic activity towards enteric pathogens and/or provide demonstrated health benefits (Spanggaard et al., 2001; Balcázar et al., 2006a; Vine et al., 2006; Farzanfar, 2006; Gómez and Balcázar, 2008; Singermann, 1990; Vijayan et al., 2006; Hai et al., 2007; Kesarcodi-Watson et al. 2008; Chythanya et al., 2002; Seddik et al., 2017). A list of probiotic bacteria (Irianto and Austin, 2002b; Panigrahi et al., 2004, 2005; Aubin et al., 2005a; Kim and Austin, 2006a; Balcázar et al., 2007a,b; Bagheri et al., 2008; Merrifield et al., 2010a,b,c,d) used commercially is given below:

Lactobacillus species: *L. acidophilus, L. casei, L. fermentum, L. gasser,. L. Johnsonii, L. Lactis, L. Paracasei, L. Plantarum, L. reuteri, L. rhamnosus, L. salivarius,*

Bifidobacterium species: *B. Bifidum, B. Breve, B. Lactis, B. Longum*

Streptococcus species: *S. thermophilus*

Saccharomyces cerevisiae **(a yeast)** which have probiotic features also has been usually studied to demonstrate immunostimulatory activity and production of inhibitory substances as observed in probiotic.

3.1 Action Mechanisms of Probiotics

3.1.1 Production of Incompatible Compounds

Antagonistic compounds are described as chemical substances produced by bacteria which are toxic or inhibitory towards other microorganisms or they have a bactericidal or bacteriostatic effect on other microbial populations. These substances may be produced as either primary or secondary metabolites and therefore have different modes of inhibitory action. The bacteria which produce inhibitory substances in the GI tract of the host (in vivo) or in its culture medium (in vitro) are thought to become a barricade against the propagation of opportunistic pathogens for example lactic acid bacteria which act as a probiotic produces bacteriocin and bacteriostatic substances which help to inhibit the growth of other microorganisms (Ghosh et al., 1996; de Valk and Marx, 1999; Kontoghiorghes, 2005; Dam, 2005).

3.1.2 Competition for Chemicals or Available Energy

Iron is the element which essentially required for the growth of all microorganisms but its solubility is very low, therefore its bioavailability is poor. To cope up the low availability of iron, Siderophores are used as an ion-specific chelating agents of ferric ions which can be dissolved precipitated iron and make it easy for microbial growth (Budzikiwwicz, 1997; Meyer and Stintzi, 1998; Meyer et al., 2002; Eberl and Collinson, 2009; Manual et al., 2008). The siderophores has the capability resides in their capacity to search an essential nutrient present in the environment and remove competitors to use of it. The bacterial pathogens are successful to compete for iron in the highly scarcity of iron in tissues and body fluids of the host. Those harmless bacteria which can produce siderophores can also be used as probiotics to compete with pathogens whose pathogenicity is known to be due to siderophore production and competition for iron or to outcompete all kind of organisms requiring ferric iron from solution ((Sugita, 2011; Hedia and Hermann, 2011).

3.1.3 Competition for Adhesion Sites

The pathogenic bacteria adhere to the gut wall or the surface of other tissue to harm these sites, to prevent colonization of these pathogenic bacteria is to compete with probiotic bacteria for adhesion. In order to that probiotics have more potential to attach the enteric mucus and wall surfaces for competition to pathogenic bacteria. Since bacterial adhesion to tissue surface is important at the primary stages of pathogenic infection, competition for adhesion receptors with pathogens might be the first probiotic effect. The intestinal bacteria isolates which compete efficiently with the pathogenic bacteria for the attachment to the mucosal intestinal surface are best observed in case of turbot fish. (Sugita et al., 1996, 1997; 1998; Vershuere et al., 2000; Olafsen, 2001; Vine, 2004; Gatesoupe 2008; Gòmez and Balcàzar, 2008; Ringø, 2008; Tinh et al., 2008).

3.1.4 Enhancement of the Immune Response

Immunostimulants are chemical compounds that stimulate the immune systems of human as well as animals and make them more resistant to infections by viruses, bacteria, fungi, and parasites. Probiotic (lactic acid) bacteria administered orally may induce increased resistance to enteric infections has been observedin warm blooded animals (William et al., 2006; Macrthy et al.,2003; Zoumpopoulou et al., 2008; Lamine et al.,2004; Peran et al., 2007; Lee et al.,2008; Rachmilewitz et al.,2004; Di, 2005; Smits et al.,2005; Schultz et al., 2003; Schultz et al., 2000; Pronio et al., 2008; Gionchetti et al.,2000; Mimura et al., 2004; Spiller, 2007 and Martin et al., 2006; Matis et al., 2015).

3.1.5 Colonization and adhesion

It is stated above that a candidate probiotic which supplied on a regular basis is able to colonize and survive in the host or in it compatible environment. The ability of a probiotic strain to colonize into the gut of the host and quality of its to attach with the mucus layer of gut and the capacity to prevent the establishment of potentially pathogenic bacteria might be proved as good preselection criterion for appropriate potential probiotic among the putative probiotics (Wilson and Perini, 1988; Katayawa et al**.**, 1997; Bernet et al., 1993; Katouli et al., 1997; Duffy et al., 1997; Conway et al. 1987; Goldin et al. 1992; Kleeman and Klaenhammer, 1982). Probiotics play an essential role in competitive prevention of bacterial attachment on the parts of GI tract of the host body. Therefore, certain probiotics strains have been considered according to their capability to adhere with the epithelial cells. (Conway et al. 1987, Goldin et al. 1992, Kleeman and Klaenhammer 1982). The first probiotic effect shows competition for adhesion receptors with pathogenic bacteria and Some bacteria have antiviral effects also for e.g. Bacillus foraminis and B. cereus biovartoyoi exhibited antagonism against Streptocoscus iniae and Photobacterium damselae (Montes & Pugh 1993; Wang et al., 2008; Guo et al. 2009; Sharma et al., 2017a,b).

3.1.6 Improvement of water quality

Research observed that the addition of the probiotics into the water, especially *Bacillus* strain of bacteria has been improved the water quality. The reason behind it that gram-positive *Bacillus* spp. is usually more effectual in transforming organic matter into CO_2 than are gram-negative bacteria, which convert organic matter into bacterial biomass or slime (Stanier, 1993). The rationale is that by sustaining higher levels of these gram-positive bacteria, farmers can minimize the accumulation of dissolved and particulate organic carbon during the production of pond and these bacteria release inhibitory compound such as bacteriocines, lysozymes, proteases, and hydrogen-peroxide which make an antagonistic environment for pathogens (Nogami and Maeda, 1992; Jory, 1998; Moriarty, 1998; Verschuere et al., 1999; Ruiz-Ponte et al., 1999; Douillet, 2000b; Chythanya et al., 2002;Balaczar et al., 2007)

Probiotic research in other animals

While there has been a long standing interest in probiotics, increased concern that overexposure to antibiotics is resulting in the generation of treatment resistant strains of bacteria, compounded by the imminent ban on the use of antibiotics as feed additive. Thus, studies on the efficacy of different strains of direct fed microbials (DFM), alone or in conjunction with other bacteria, and also on the mode of action in production animals are becoming increasingly refined and important. Many different benefits have been attributed to the consumption of probiotics in both humans (Fuller, 1989; Saavedra *et al*., 2004; Connolly *et al*., 2005; Sartor, *et al*., 2005) and in animals, most notably production animals such as cattle and chickens. Benefits include increased lactose tolerance and improved immunity in human and increased feed efficiency and decreased pathogen shedding in animals (Marteau and Bputron- Ruault, 2002). A healthy balance of microflora of the gastrointestinal tract is crucial to the health of an animal as well human (Ryanet al., 2015). Current production methods lead to heavy stress which can have negative effects on the performance of animals, especially on young ones whose gut microflora is not yet established. DFM have been reported to moderate the negative effects which such practices have on the health of the animals. Beef cattle undergo severe stress in the process of weaning, transport, fasting, assembly, vaccination, castration, and dehorning. Such stress can lead to an imbalance in intestinal micro flora, leading to increased morbidity and even death. A number of studies have indicated that treatment with DFM can help to restabilize the gut microflora, thereby improving overall health and performance of animal. Feed supplemented with probiotic bacteria has been shown to reduce the numbers of pathogenic bacteria in cattle rumen and feces (Huber, 1997). DFM activity is limited to the gastro intestinal tract in most species while it includes the rumen in ruminants. In these animals, DFM use has been accredited with enhanced milk production in dairy cows, improved feed efficiency and daily gain in beef cattle (Nathanon and Chantelle, 2006). This study supports the others which suggest that DFM use is most effective in times of environmental or physical stress on the host and that effects are less noticeable on healthy hosts.

Probiotics in broilers

It has been found that *Lactobacillus* and *Enterococcus* are the most common intestinal bacteria present in poultry and *Lactobacillus* treatment in broilers resulted in improved immunity in bird that have deficiency of Vitamin A and were also able to demonstrate the effect of probiotic on local cell mediated immunity in chickens. This was evidenced by an apparent decrease in intestinal invasion by the pathogen *Eimeria acervulina* based on a higher serum level of Interlukin-2. *Salmonella entérinais* is a major food borne illness found in poultry and raw meat contamination has significant commercial implications Dalloul *et al.* (2003) Tellez *et al*. (2006) found that combining probiotics *L. acidophilus* and *Streptococcus faecium* with antibodies against *Sal. entérinais, Sal. typhimurium* and *Sal. heidelberg* successfully reduced the disease. Other studies have found that probiotics had a positive effect on chick weight gain (Zulkifli *et al*., 2000).

Probiotics in Horses

Horses are classified as herbivores, or roughage eaters and has its digestive system has a great potential to assimilate large quantities of high fiber forage on regular basis. The digestive system of the horse is considered as monogastric rather than ruminant not like most other herbivores. The stomach and small intestine are the part of the upper gut where most of the biomolecules like protein, fats, vitamins and minerals are digested and absorbed. The large intestine of the horse ends into an enlarged cecum where fermentation of food takes place. In the process of fermentation cellulose and hemi-cellulose fibers, (which are present in hay, especially stems and stalks) are broken down into its smaller sub unit that are utilize by the horse. There are so many beneficial micro-organisms like bacteria and protozoa which produce enzymes that break down plant fiber having cellulose. Cellulose is the chief constituent of the cell in the most plants. Bacteria lives in the large intestine of the horse act as probiotic which help the horse in digestion of cellulose. Combination of pre and probiotics are designed to support the natural microbial population of the gut that contains legal live yeasts which are proven to support the health of the horse's gut.

Horse is a powerful animal and requires a high energy diet for competition and modern management thus, it depend on the assistance of billions of beneficial micro-organisms which live in the gut (Shen et al., 2013). The enzymes produced by these bacteria convert their food into its basic constituents of their respective component which can be easily assimilated by the gut wall of horse. The essential minerals such as calcium and zinc can easily digest with the help pf probiotic and it also aids in the production and bioavailability of vitamin B. The antimicrobial property of the probiotics inhibits the production of harmful microbial community, its illness and also exclude harmful bacteria through competition for space and nutrients by colonization into the gut. Lactating mares have shown benefited to probiotics through the Improvement of quality and quantity of milk which can stimulate the initial growth of foals and also decrease the death in foals.

Thus, probiotic provides a healthy micro-flora in the horse gut that help them to improve general health, appearance, body structure and its performance along with its immunity power. Probiotic may prove an effective prophylactic measure when a horse Consume sand and dirt along with their food that can create obstruction in gastrointestinal tract that may lead into different illness like chronic diarrhea, weight loss, and colic (**Allen et al., 2008).** If a horse has an upset because of grain overload then adding more *Lactobacillus* in diet is the last thing to do, since it's the *other* species that are going to be adversely affected.

Conclusion

Microbiota of living organisms present in the gastrointestinal tract plays a vital role in terrestrial as well as aquatic animals along with humans to stimulate the digestive processes and also in improving the health of the host. Probiotics generates a useful effect on the host by administration of live micro-organisms such as those in traditional yoghurt and other fermented foods or in powders, tablets, liquid suspensions and lyophilized in capsules. They have considerable therapeutic advantages. They have the ability to prevent and treatment of a variety of intestinal disorders, aid in preventing intestinal bacterial enzymes involved in the production of colonic carcinogens. Probiotics are proving itself in modulation of immune function of the host, humoral, cellular and non-specific immunity in the host body. Some advantages of probiotics over conventional therapy include virtually low cost in addition to the fact that probiotics are not expected to increase the incidence of antibiotic resistance or the mechanisms in which probiotics may suppress pathogens (resulting in reduction the extent of resistance against the probiotic). Prebiotics may be more efficient than probiotics in obtaining colonic bacterial adaptation to provide beneficial effects on colonic disease and also affecting lactose intolerance. Basically prebiotic foods have certain absorption, fiber contribution, gut integrity, immune function, cholesterol control and also in the treatment of constipation and hepatic encephalopathy. They can protect against some intestinal pathogens and may be helpful in some inflammatory bowel disease. They can have some anticarcinogenic influences. Prebiotics are also able to facilitate mineral absorption into the bone of the host and aid to protect the bones against osteoporosis. In addition, certain prebiotics are believed to be effective on diabetes mellitus. Simultaneous taking of prebiotics and probiotics may develop the potential effectiveness of both the probiotics and the prebiotics. The growing demands of natural alternatives over conventional medicine are expected to improve the prebiotic market.

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