**Synbiotics future food supplement for Companion Animals**

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**Introduction:**

The companion animals are fed to promote to promote their life long health for their owners at the same time to economize the balanced ration for their good health. Nutritional needs of the animals are influenced by their life style as well as life stage. Balancing the diet for companion animal are very perplexing because of the different tangled factors. Since these animals are very particular and sensitive for their feed but mostly they are fed as per the dietary preference of their owners. Meeting the nutritional requirement together with maintaining the overall health and precisely the gut health possess great challenge to the nutritionist. There are many challenging stages in the life of companion animals where they need extra attention particularly in obese, geriatric and sick animals. In this regards synbiotics has emerged as one of the potent alternative for meeting the various expectation of meeting all challenges. Synbiotics in animal feeding context may be defined as the mixture embracing probiotics (live microorganisms) and prebiotics (selectively digestible nutrients/substrates) and confers beneficial effect to the host animals by promoting growth of beneficial bacteria in their colon. Broadly these synbiotics may be categorised into (a) Complementary synbiotics: with independent probiotics and prebiotics combination, and (b) Synergistic synbiotics: Related prebiotics and probiotics combination (Swanson et al.,2020).

The advantage of using synbiotic may to cater the beneficial effect of both probiotics and prebiotics simultaneously as the prebiotics may provide the substrate and environment necessary for colonization and growth of probiotic microorganism and their rapid multiplication (Sekhon and Jairath 2010; Malik et al. 2016). Thus, a proper grouping of both probiotic and prebiotic in a single product should results in better effect, compared to their alone activity. A large permutation and combination combinations, provides a large number of possible promising synbiotics for their application in human and other animals for the modulation of gut microbiota and other beneficial effects (Kearney and Gibbons 2018). The commonly used probiotic microorganisms include *Lactobacillus rhamnosus, Lactobacillus reuteri, bifidobacteria*, and certain strains of *Lactobacillus casei; Lactobacillus acidophilus* group; *Bacillus coagulans*; *Escherichia coli strain Nissle 1917*; *Enterococcus faecium* SF68; *Bifidobacterium sp. (B. animalis, B. longum, B. pseudolongum, B. thermophilum*), and the yeast *Saccharomyces boulardii*. (Pandey et al. 2015; Malik et al. 2016; Ojha et al., 2020). Nevertheless with advancement in technology along with intensive research many new strains and genera of probiotics have been emerged and raised.

The commonly used prebiotics are inulin sources (like Jerusalem artichoke, chicory roots, etc.), raw oats, and nondigestible oligosaccharides. Which may include fructooligosaccharides (FOS), galactooligosaccharides (GOS), transgalactosylated-oligosaccharides (TOS) and lactulose. Recently, some more substrates are being investigated and included in the list as emerging prebiotics like genti-oligosaccharides, glucooligosaccharides, lactosucrose, levans, pectic oligosaccharides, resistant starch, and xylooligosaccharides (XOS) (Anadon et al. 2010; Pandey et al. 2015). These prebiotics mostly indigestible in the upper digestive tract may got fermentation in the colon thereby increasing the population of *bifidobacterium* which synthesis compounds that inhibit potential pathogens, as they tends to lower blood ammonia levels and produces digestive enzymes (Malik et al. 2016).

The application of synbiotics provides a potential substitute to the antibiotics and reduces the chance of resistance problem arising now a days. It has synergistic benefits over other alternative including probiotics and prebiotics being used alone. The noteworthy enhancement in the short chain fatty acid (SCFA), ketones, carbon disulphide, and methyl acetate after the supplementation of synbiotics has further strengthened their point for promising alternative and supplement for animal usage for health-promoting effects (Vitali et al. 2010). In the recent time research studies are emerging for testing the benefits of synbiotics with special emphasis on their application as health promoter and theraputive agent. Additionally, synbiotics have been verified by many researchers for their effect on other indices such as growth rate, nutrient absorption, and quality of meat, milk, and eggs. Synbiotics inclusion may tends to improve the survivality of the probiotic microbiota during the passage through the upper intestinal tract and may contribute to maintain the intestinal homeostasis in terms of immune function and microbial population and confers health benefits. Compared with probiotics and prebiotics, synbiotics are the least investigated substances with respect to animal health and performance especially in companion animals. This chapter describes the current knowledge and research activities conducted or going on to extract the effects of synbiotics on the health and performance. The mode of action, beneficial effects, and demonstrated study results proving the efficacy of synbiotics in companion animals are explained.

**Synbiotics for Animals**

The colonized microbes present in the intestine of animals confers immunological, physiological, nutritional, and protective functions for the host and being supposed to get influenced by the type of food. The synbiotics has emerged as an potential alternative to be used for livestock and poultry feed which could to yield greater health effects along with affecting growth performance, feed conversion ratio, haematological and biochemical parameters than the individual use of probiotic and prebiotic alone. Synbiotics supplementation reported to modify the population of beneficial microorganism at the same time promoting the general health parameters of gut. Even though studies on the effects of synbiotics on livestock health and performance are very limited, and the beneficial effect of synbiotics may be attributed and depends mainly on the synbiotic combination (Scavuzzi et al. 2014). The mode of action is a synergy between probiotics and prebiotics and explained in figure no 1.

**Effect**

The effect of synbiotics is very much dependent upon the choice of the synbiotic combination of both prebiotics and probiotics. The prebiotic component within a synbiotic product should support the growth of the probiotic and enhance its proliferation within the gastrointestinal tract. Even though combinations of prebiotics with dietary probiotics have limited investigation especially among the domestic canine and feline species. Ogué-Bon et al. (2010) conducted *in vitro* experiments to evaluate the synergistic potential of prebiotics FOS, GOS, and inulin and probiotic strains *Bifidobacterium bifidum* 02450B*, Bifidobacterium longum* 05, *Lactobacillus plantarum* 115400B, *Lactobacillus acidophilus* 14150B, *Lactobacillus acidophilus*, and *Lactobacillus rhamnosus*. They inferred that the synbiotic combination GOS and *Bifidobacterium bifidum* 02450B confers higher modulation of canine fecal microbiota as compared with GOS alone. Recently, Schmitz and Allenspach (2017) in an in vitro study investigated the growth properties of *Enterococcus faecium* NCIMB 10415 E1707, *Enterococcus faecium* NCIMB 30183, *Bifidobacterium longum* NCIMB 30182, and *Bifidobacterium infantis* NCIMB 30181, with the addition of FOS, MOS, and FOS plus gum Arabic. They observed growth of bifidobacteria with commonly used prebiotic oligosaccharides, however the addition of gum arabic may lead to higher growth rate than FOS alone. White et al.,2017 studied the effects of *Lactobacillus acidophilus* NCFM, FOS, or their combination for gut microbial populations, fermentative end products, and nutrient digestibilities in healthy adult dogs. The synbiotics supplementation enhances the population of beneficial microbial (e.g., *bifidobacteria, lactobacilli*) and lowers population of potential pathogens (e.g*., Clostridium perfringens*). Further, they also recorded enhancement in gut health as evident by increasing fecal butyrate and lactate concentrations and decreasing several putrefactive compounds present in feces. *Lactobacillus acidophilus* combined with FOS addition also reported to increase the concentration of bacterial metabolites. In particular, the synbiotic was effective in reducing the fecal concentrations of ammonia and putrefactive compounds including branched chain fatty acids, biogenic amines, phenols, and indoles to a greater extent as compared to either probiotic or prebiotic alone (Swanson et al. 2002). Even though supplemental synbiotics may be useful in introducing beneficial bacterial populations and have potential to encourage proliferation of symbiotic strains in the intestinal tract, the studies related to prevention of diarrhoea and other gastrointestinal upsets with supplementation of synbiotics is barely studied in companion animals. Gagné et al. (2013) demonstrated that supplementation of synbiotic (*Enterococcus faecium* SF68, *Bacillus coagulans*, and *Lactobacillus acidophilus* along with FOS and MOS) resulted in proliferation of *Lactobacillaceae,* together with butyrate concentration, and improvement in fecal score and overall reduction in the prevalence of diarrhoea in dogs. On the other hand, unaltered bacterial population together with intestinal health and immunological (IgA, trypsin-like immunoreactivity, and pancreatic lipase immunoreactivity) indicators were reported after administration of synbiotics having multiple combination different probiotic species (*Enterococcus faecium* NCIMB 30183, *Streptococcus salivarius* subsp. thermophilus NCIMB 30189, Bifidobacterium longum NCIMB 30179, *Lactobacillus acidophilus* NCIMB 30184, *Lactobacillus casei* subsp. rhamnosus NCIMB 30188, *Lactobacillus plantarum* NCIMB 30187, Lactobacillus delbrueckii subsp. bulgaricus NCIMB 30186) and a blend of FOS and arabinogalactans daily for 21 days in healthy dogs and cats (Garcia-Mazcorro et al. 2011). In a recent study, Rose et al. (2017) examined the efficacy of a synbiotic supplement on the incidence of diarrhoea in a dog shelter and observed a significant lowering of incidence of diarrhoea among the dogs administered with *Enterococcus faecium* NCIMB 10415 4b1707 and FOS. Hart et al. (2012) assessed the outcome of a synbiotic formulation comprising of multistrain probiotics (*Enterococcus faecium* NCIMB 30183, *Streptococcus salivarius* subsp. thermophilus NCIMB 30189, *Bifidobacterium bifidum* NCIMB 30179, *Lactobacillus acidophilus* NCIMB 30184, *Lactobacillus casei* subsp. rhamnosus NCIMB 30188, *Lactobacillus plantarum* NCIMB 30187, *Lactobacillus delbrueckii* subsp. bulgaricus NCIMB 30186) and two prebiotics in adult cats and reported improvement in the faecal score from 6.0 to 4.4 and lowering of incidence of diarrhea in cats. Stokes et al. (2017) demonstrated that synbiotics could improve and can be used as an alternative to antibiotics for therapeutic usage in cats suffering from gastrointestinal disorders as they found that administration of the synbiotic 1 h after clindamycin induced hyporexia and vomiting subsides in cats. Some more effect of synbiotics application and their potential effect has been summarised in table no 1.

Antimicrobial production

Prevent colonization of pathogens

Improves Intestinal microflora

Immunomodulation & cholesterol reduction

Short chain fatty acid production

Toxin Neutralization

Improves nutrient absorption

Improves epithelial barrier function

Reduces pH of colon

Figure 1: **Mode of action of synbiotics**: Synbiotics produces synergistically effect of prebiotics and probiotics as they improve gut health by improving the gut barrier function by modulating the intestinal growth along with modification of colonic microbiome and altering the pH. They also secret antimicrobial component like bacteriocin, nicin etc and prevent colonization of harmful bacteria either by competitive inhibition of substrate consumption. They also improve general health as they are reported to enhance the immune modulation, production of short chain fatty acids like butyrate that provides energy for enterocytes growth and proliferation. Reports of increased nutrient absorption like iron, zinc, and calcium and toxin neutralization has also been recorded as they tends to increase the villus height and alter their morphology. Synbiotics may also be recognized by protein coupled receptors (GPR) expressed on polymorphonuclear immune cells, enterocytes and enteroendocrine cells stimulating the chemokine and cytokines expression, such as, pro-inflammatory IL-2 and interferon (IFN)-γ and immuno-regulatory IL-10 production.

Table 1 Effects of some synbiotics on health and growth performance of dog and cats

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| --- | --- | --- |
| Synbiotic | Main outcome | References |
| *Enterococcus faecium* (EF) and fructooligo-saccharides) | There was increase in microbiota taxonomic composition | Pilla et al., 2019. |
| Yeast synbiotic containing 1 x 1010 CFU of *Saccharomyces boulardii* and the prebiotic beta‐glucan | Decreased derangements in mean food intake of infected dogs. Improvement in the faecal score of dogs. | Whittemore et al., 2019. |
| Cats: Proviable‐DC, commercial grade | Decrease in incidence of antibiotic induced hyporexia and vomiting in healthy cats. Alleviation of antibiotic‐associated gastrointestinal signs (AAGS) in cats | Stokes et al.,2017 |
| *Lactobacillus acidophilus* D2/CSL (CECT 4529) with FOS | Improvement of faecal parameters of dogs, meaning that the supplement helps to maintain the optimal balance of their intestinal microbiota. | Bruni et al.,2020 |
| Dogs: Synbiotic prepared using a combination of *Lactobacillus*  *acidophilus* NCDC15 fermented milk and Cichorium intybus root powder | The digestibility of crude fibre increases.  Further, faecal lactate and *lactobacilli* and *bifidobacteria* population was increased. reduction in faecal ammonia and population of clostridia and coliform. The delayed‐type hypersensitivity response showed improved immune status | Kumar et al.,2021 |
| Dogs.  The synbiotic used is commercial preparation Proviable R -Forte, | Decreased antibiotic-induced gastrointestinal effects in dogs administered synbiotics | Whittemore et al.,2021 |

**Conclusions:**

There are indication suggesting beneficial effects of synbiotics in the companion animals. As some studies suggest that synbiotics are having positive influence on the intestinal microbiota of companion animals and play role in the improvement of performance and maintenance of optimal health. Along with these effects, they also tend to enhance the number of beneficial intestinal microorganisms and the reduction of the potential pathogen load, stimulation of immunological response. However, their dose optimization with varying breeds and species are very scanty and needs to be established. More studies are also needed to strengthened the extended shelf life and keeping qualities of these products. This aspect posses a great challenge as well as opportunity for augmenting their usage together with maintaining safety and economics of usage. The different ways to increase their palpability and intake also needs to be investigated properly for their recommendation to be used as a regular supplement for companion animals to ensure their long and healthy life. These further open new avenues for these products to be used by clinicians to prevent the indiscriminate use antibiotics.

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