Prebiotics in animal feeding

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Abstract

A prebiotic is defined as a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria. Fructo oligosaccharides (FOS), galactooligosaccharides (GOS), xylooligosaccharides (XOS), isomalto oligosaccharide (IMO) and lactulose alter the microflora, increasing the level of bifidobacteria and lactobacilli. They inhibit pathogens through competition with receptor sites on the gut wall and inhibit pathogen persistence and thus reduce the potential risk of infection. They may also compete effectively for nutrients with pathogens. Prebiotics manipulate the microbial intestinal environment and subsequently prevent the occurrence of infectious bowel disease. It may influence the immune system directly or indirectly as a result of intestinal fermentation and promotion of growth of certain members of the gut microbiota.

Keywords: Animal, gut, health, prebiotics

Introduction

A prebiotic is a food or dietary supplement product that confers a health benefit on the host associated with modulating the microbiota. Prebiotics are not drugs, not functioning because of absorption of the component, not due to the component acting directly on the host, and are due to changes to the resident bacteria – either changing the proportions of the resident bacteria or the activities thereof (WHO, 1994) [1]. A prebiotic may be a fibre, but a fibre is not necessarily a prebiotic. Symbiotics refer to nutritional supplements combining probiotics and prebiotics in a form of synergism, hence symbiotics. Prebiotics that beneficially affect the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract, by selectively stimulating the growth and/or by activating the metabolism of one or a limited number of health-promoting bacteria, thus improving host welfare (Saarela et al., 2000) [2]. A prebiotic is a fibre such as fructose oligosaccharide, galactose oligosaccharide, etc. and is consumed that is intended to stimulate the microflora in the large intestine. Prebiotic has shown to increase the population and/or function of the probiotic, as the probiotic is an external species, whereas prebiotics stimulate the flora which is already present (Fuller, 1992) [3]. Prebiotics are substances that can promote the growth of beneficial microorganisms, mainly in the intestinal tract, and will modify the colonic microbiota. A prebiotic is defined as ‘a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon and thus improves host health’ (Gibson and Roberfroid, 1995) [4]. The stimulated bacteria should be of a beneficial nature, namely bifidobacteria and lactobacilli (Gibson et al., 1999) [5]. A prebiotic is a selectively fermented ingredient that allows specific changes both in the composition and/or activity in the gastrointestinal microflora that confers benefits upon host well-being and health.

‘A dietary prebiotic is a selectively fermented ingredient that results in specific changes, in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health (ISAPP, 2008) [6].

However many food components, especially many food oligosaccharides and polysaccharides (including dietary fibre), have been claimed to have prebiotic activity without due consideration to the criteria required. These criteria for a prebiotics are:

1. Resistance to gastric acidity, hydrolysis by mammalian enzymes
2. Resistance to gastrointestinal absorption
3. Fermentation by intestinal microflora
4. Selective stimulation of the growth and/or activity of those intestinal bacteria that contribute to health and well-being. (Gibson et al., 2004) [7].
Owing to differences in structure, it is important to characterize and understand the collective nutritional, chemical and food science properties of scFOS as a separate fructan subgroup. scFOS is present in selected foods that include onion, artichoke, garlic, wheat and banana. scFOS is manufactured by a bioenzymatic (or fermentation) process, using sucrose from sugar beet or cane sugar as the starting raw material. scFOS has been included in a wide variety of foods and supplements globally that have been marketed for animal use.

**Physiological effects of sc-FOS:**
- Both in vivo and in vitro models have been used to demonstrate that scFOS is not digested between the mouth and small intestine. This is because neither the pancreas nor the small intestine mucosa secretes enzymes capable of hydrolyzing the β-(1→2) fructosyl fructose linkages (Czaczky, 2003) [13].
- Bacteria utilize FOS by the production of short chain fatty acids (Hosoya et al., 1998) [14]. Selective utilization of scFOS by intestinal bacteria has been demonstrated in vitro using pure cultures of selected bacterial species or using mixed faecal flora inoculations and also in animal and human studies by measuring the bacterial composition of the faeces.
- Piglets fed with sc-FOS in milk replacer develop resistance against E. coli & don’t develop diarrhoea (Bunce et al., 1995) [15].
- Bouhnik et al. (2004) [16] demonstrated that feeding of sc-FOS at 10 g/day not only increases counts of bifidobacteria but also the percentage of the bacteria among total anaerobes.

Mechanistic studies suggest that scFOS may be a better substrate for intestinal bacteria than oligofructose or inulin due to its shorter and more specific degree of polymerisation. McKellar et al. (1993) [17] suggested that scFOS was a better growth factor than inulin.

**Inulin type Fructans**

Inulin is a carbohydrate that is extremely widespread in nature. It occurs in plants mainly as an energy reserve and as a cryoprotectant. Different plant species typically contain inulin with varying chain lengths. Wheat, onions and bananas have short-chain inulins (maximal degree of polymerisation is 10); dahlia tubers, garlic and Jerusalem artichoke have medium-chain inulins (maximal degree of polymerisation is 40); and globe artichoke and chicory typically contain long-chain inulin molecules (maximal degree of polymerisation is 100) (Van Loo et al., 1995) [18]. Other plants, such as certain types of lily (Urginea maritima) and blue agave and certain bacteria (e.g. Streptococcus mutans) produce high degree of polymerisation (more than 1000).

Inulin resists hydrolysis by acid in the stomach and by human digestive enzymes. Digestive enzymes are unable to hydrolyse glucosidic bonds present in inulin (Bjorck, 1991) [19].
on composition of the intestinal flora is less pronounced (Harmsen et al., 2002) [22].

- Mixture of the long-chain inulin and short-chain oligofructose @ 1:1 may be more potent than oligofructose alone in promoting Ca absorption (Coudray et al., 2003) [23].
- The development of chemically induced breast cancer in humans was suppressed by feeding the animals a diet containing inulin (Taper and Roberfroid, 1999) [24]. This indicates that systemic effects were involved and the cancer-preventing action was carried out by continuous feeding of inulin.
- As antibiotics are being banned as growth promoters in animal feed, prebiotics such as inulin offers a good alternative. Young animals are typically fed relatively high doses of inulin [up to 2% (w/w) in feed] which directly or indirectly improves the health of the animals (Taper and Roberfroid, 1999) [24].

Galacto Oligosaccharides (GOS)

The commercial GOS products are composed of oligosaccharides ranging from disaccharides to octasaccharides (Shin and Yang, 1998) [25]. GOS have attracted particular attention because they have certain similarities to oligosaccharides occurring in human breast milk and modulate the microbial population in the gut. Thus, they affect different gastrointestinal activities and have the potential to influence inflammatory and immunological processes (Sharon and Ofek, 2000) [26]. The non-glucose and lactose components in GOS are considered non digestible oligosaccharides as judged by in vitro digestibility studies (Burvall et al., 1980) [27].

Physiological effects of GOS

- GOS is potential to stimulate the growth of bifidobacteria and lactobacilli at 1% (w/v) when fed over 24h (Tanaka et al., 1983) [28].
- GOS also supported growth of several enterobacteriaceae and streptococci.
- Hopkins et al. (1998) [29] studied the growth of a range of isolates of bifidobacterium and found significantly increased growth rates on GOS as compared with a range of other carbohydrates.
- GOS has been shown to be protective against the development of induced colorectal tumors in rats (Wijmans et al., 1999) [30].

Functional disaccharides

Lactulose

Lactulose is the first true prebiotic recognized for its effects on the gut flora. It has also been shown that small amounts (10 to 15 g twice a day) may induce tonic contractions of the colon leading to the known anti constipating effect (Jouet, 2006) [31]. Lactulose has also been used to reduce the rate of Salmonella carriage in chronic carriers (Cherrington et al., 1991) [32]. Mineral absorption, particularly calcium and magnesium, have been shown to be enhanced by ingestion of lactulose. Continuous and over feeding of lactulose may lead to obstructive Jaundice and Cirrhosis (Schumann, 2002) [33].

Lactitol

Lactitol is also derived from lactose through hydrogenation of the parent compound. Feeding of Lactitol increased both bifidobacteria and lactobacilli, but decreases the no. of bacteroids and Clostridia species (Ouwehand and Vesterlund, 2004) [34]. In a randomized clinical trial, combinations of sucrose and lactitol were evaluated at different doses for effect on faecal flora and short-chain fatty acids. While total bacteria remained constant, at the highest intake of lactitol a significant increase in bifidobacteria was observed (Balongue et al., 1997) [35]. Feeding of Lactitol also increases the Ca absorption.

Effect of prebiotics

Effect on Gut

- Prebiotics help in selective growth of some selective bacteria like lactobacillus (Nousiainen et al., 2004) [36].
- They may also inhibit pathogens through competition with receptor sites on the gut wall and inhibit pathogen persistence and thus reduce the potential risk of infection. They may also compete effectively for nutrients with pathogens (Messens and de Vuyst, 2002) [37].
- It is also acknowledged that it may reduce the risk of colon cancer through stimulating apoptosis (Scheppach, 1996) [38].
- Feeding of Prebiotics develop resistance to gastric acidity, hydrolysis by mammalian digestive enzymes and GI absorption. (Gibson et al., 2004) [39].

Effect on Immune System

- Prebiotic effects may influence the immune system directly or indirectly as a result of intestinal fermentation and promotion of growth of certain members of the gut microbiota.
- Presence of increased numbers of a particular microbial genus or species or a related decrease of other microbes, may change the collective immuno-interactive profile of the microbiota (Caplice and Fitzgerald, 1999) [40].
- Microbial products such as short chain fatty acids (SCFA) may interact with immune cells and enterocytes and modify their activity (Isolauri et al., 2001) [40].

Effect on Gastrointestinal Disorder

- Prebiotics are able to manipulate the microbial intestinal environment and subsequently prevent the occurrence of infectious bowel disease (Sartor, 2005) [41].
- A number of prebiotics have been demonstrated to be effective in the manipulation of the microbiota. These include inulin, germinated barley foodstuff (GBF) and oligosaccharides such as oligofructose. (Guarnier, 2007) [42].
- A mixture of various prebiotics decreased the incidence of bloody diarrhoea and mucosal injury (Kanauchi et al., 1998) [43].
- Gut microbiota may interfere with the process of carcinogenesis. Increasing the proportion of lactic acid bacteria in the gut may lead to decrease in certain bacterial enzymes involved in the synthesis or activation of carcinogens (Alakomi et al., 2000) [44].

Effect on Mineral Absorption

Prebiotic increases Ca, Mg, Fe and Zn absorption in various species of animals. Prebiotics are resistant to hydrolysis by small intestinal digestive enzymes. The colonic fermentation produces SCFA and other organic acids that contribute to lower luminal pH in the large intestine which, in turn improves the passive diffusion (Lopez et al., 2000) [45].
Conclusion
Prebiotics improve the performance of an animal by improving feed conversion and daily weight gain. It can improve digestive problems and general health of an animal.

References