EFFICIENCY OF PROBIOTICS AND PREBIOTICS IN FARM ANIMALS

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Abstract

The determination of probiotic term was notified by Fuller (1989): viable micro-organisms that should lead to beneficial effects for the host animal due to an improvement of the intestinal microbial balance, or the properties of the indigenous micro-flora (Havernaar et al, 1992). Probiotics have been defined by Collins and Gibson (1999) as "a live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance". This description on the mode of action of probiotics shows that there still is no consistent data to precisely explain probiotics effects. Our knowledge about the mode of action of probiotics is very limited (Simon et al 2003). Prebiotics are defined as "a nondigestible 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" (Gibson and Roberfroid, 1995). Combination of prebiotics and probiotics are known as synbiotics. Oligosaccharides are commonly fed to weanling pigs in Japan and are increasingly being used in Europe (Ficklinger, 2000; Monsan and Paul, 1995; Piva, 1998), however their use is just beginning to increase in the US. These alternatives to growth promoting antibiotics act by enhancing the three primary defense systems against pathogens: the intestinal microbiota, epithelial cell renewal, function and immune function (Patterson and Burkholder, 2003).

Key words: probiotics, prebiotics, performance parameters, farm animals

Table 1. Micro-organisms authorized for the use as feed additives in the EU, Simon et al 2003.

Micro-organism	Strain	Species or category of animal
Bacillus cereus var. toyoi	NCIMB 40112/ CNCM I 10121	Chickens for fattening, laying hens, calves, cattle for fattening, breeding does, rabbits for fattening, piglets, saw.
Saccharomyces cerevisiae	NCYC sc 47	Rabbits for fattening, sow, piglets, dairy cows.
Saccharomyces cerevisiae	CBS 493.94	Calves, cattle for fattening, dairy cows.
Saccharomyces cerevisiae	CNCM I- 1079	Sows, piglets.
Saccharomyces cerevisiae	CNCM I- 1077	Dairy cows, cattle for fattening
Enterococcus faecium *Enterococcus faecium*	ATCC 53519 ATCC 55593	Chickens for fattening
Pediococcus acidilactici	CNCM MA 18/5M	Chickens for fattening, pigs, piglets for fattening
Enterococcus faecium	NCIMB 10415	Chickens for fattening, pigs for fattening, sows, cattle for fattening, piglets, calves.
Enterococcus faecium	DSM 5464	Piglets, chickens for fattening, calves.
Lactobacillus farciminis	CNCM MA 67/4R	Piglets
Enterococcus faecium	DSM 10663 NCIMB 10415	Piglets, calves, chickens for fattening.
Saccharomyces cerevisiae	MUCL 39885	Piglets, cattle for fattening
Enterococcus faecium	NCIMB 11181	Calves, piglets.
Enterococcus faecium *Lactobacillus rhamnosus*	DSM 7134 DSM 7133	Calves, piglets.
Lactobacillus casei *Enterococcus faecium*	NCIMB 30096 NCIMB 30098	Calves
Enterococcus faecium	CECT 4515	Calves, piglets.
Streptococcus infantarius *Lactobacillus plantarium*	CNCM I-841 CNCM I-840	Calves
Bacillus licheniformis *Bacillus subtilis*	DSM 5749 DSM 5750	Sow, piglets, pigs for fattening, chickens for fattening, turkeys for fattening, calves.
Enterococcus faecium	DSM 3530	Calves.

Table 2 Prebiotics oligosaccharides studied or in use Patterson and Burkholder (2003).

Arabinoxylan	Isomaltose (IM)
Agarooligosaccharides (AOS)	Lactosucrose
Cyclodextrins	Lactose
Fructooligosaccharides (FOS)	Lactulose
B-Galactooligosaccharides (GOS)	Mannanoligosaccharides (MOS)
Raffinose, stachyose	Oligofructose
Glucosyl sucrose (GlcS)	Sucrose thermal oligosaccharide caramel (STOC)
Isomalturose (IMT)	Xylooligosaccharides (XOS)
Inulin	

Combination of prebiotics and probiotics are known as synbiotics. Oligosaccharides are commonly fed to weanling pigs in Japan and are increasingly being used in Europe Ficklinger (2000), Piva (1998), however their use is just beginning to increase in the US. All of this approach attempt to decrease colonization of the intestinal tract by pathogens and to enhance the pig's defense system. These alternatives to growth promotant antibiotics act by enhancing the three primary defense systems against pathogens: the intestinal microbiota, epithelial cell, function and immune function Patterson and Burkholder (2003).

Probiotics and prebiotics effect on the immune system.

Probiotics

The mucosal surface of the intestinal tract represents the largest interface between the body and its environment. An effective local immune is necessary to protect the organism against the invasion of noxious antigens and microbes. No other organ of the body harbours more immune cells than the gut – associated lymphoid tissue (GALT), and a tremendous amount of antibodies is secreted into the intestinal lumen to neutralize and exclude harmful antigens. In numerous studies it has been shown that bacterial colonization influences the function of immune cells belonging to the GALT and even affects the systemic immune system Mitsuama et al (1986). Immune suppression has been observed after associating germfree rodents with defined bacterial species Scharek et al (2000). The numerous studies have reported immune stimulating abilities for different bacterial species. For example, *in vitro* cytokine production of macrophages was stimulated by *Bifidobacteria* Marin et al. (1997). *Bifidobacterium longum* as well as several other lactic acid bacteria have been found to increase the total amount of intestinal IgA Vitini et al (2001). *Lactobacillus casei* was reported to have immunoadjuvant activity Perdigon et al (1991) and *Lactobacillus plantarum* was shown to increase antibody production against *Escherichia coli.* Induction of cytokine profiles by lactobacilli is likely to be strain-dependent Maassen et al. (2000). Probiotic treatment using *Bifidobacterium lactis* HN019 reduced weanling diarrhoea associated with rotavirus and *Escherichia coli* infection in a piglet model Shu et al. (2001). Information from studies is also available about the age-dependent development of different immune cells in the intestine of the newborn and adult pigs Vega-Lopez et al. (2001).

Prebiotics

The intestinal microbiota, epithelium and immune system are effective barriers against pathogen colonization. However, when pathogens successful in colonizing the intestinal tract, the immune system responds with an inflammatory and/or an antibody response. There is increasing understanding of the extensive amount of cross-talk between these systems McCracken and Lorenz (2001). Stress suppresses the ability of these systems to inhibit pathogen colonization, with a resultant increased incidence of infection Soderholm and Perdue (2001). Colonization and development of clinical or subclinical infections are the result of the outcome of host-pathogen interactions and are influenced by host defense capability and pathogen virulence Casadevall and

Pirofski (1999). The mucosal immune system develops oral tolerance to the indigenous microbiota and food antigens, resulting in an accumulation of IgA secreting B cells, T cells, macrophages and denditric cells. In essence the mucosal epithelium elicits a mild or controlled Th1 or inflammatory response. This allows the mucosal epithelium to respond more rapidly to pathogen challenge however, It's expensive from an energetic standpoint to maintain in the absence of pathogen challenge Anderson et al (2000). When the animal is stressed, the hypothalamic-pituitary axis (HPA) responds by secretion of corticosteroids and direct neuronal stimulation of the mucosal tissues. The mucosal response is suppression of the Th1 response and mild potentiation of the Th2 response, Petrovsky (2001).

Efficiency of probiotic in farm animals.

Since probiotics are discussed as alternatives to antimicrobial growth promoters their impact on performance of farm animals is of prime interest. For authorization of microorganisms as feed additives it is also required to show significant effects on performance data Simon et al (2003). By far most experiments were performed with piglets. According to a litterature review in Tuschy (1986) no significant positive effects could be found from the hitherto results with piglets and fattening pigs. Later, the evaluation of studies conducted with raising piglets drew a different picture Freitag et al (1998). Tuschy (1986) was used the strict criteria of biostatistics and only significant effects were documented. Today, trends without statistical significance are also considered as positive effect Simon et al (2003). It is obvious that majority of the experiments show trends toward positive effects, however the significance level of $p \leq 0,05$ was reached only in 5% of experiments. In a trial with 90 treated and 90 untreated *Bacillus cereus* – preparation weaned piglets, the probiotic treated animals gained 7% more live weight during 6 weeks after weaning with a reduced feed conversion ratio of 2.4%. Both results were not significant Jadamus (2001). This point towards a high variation in the response of the individual animals to this type of feed additives Simon et al (2003).

Reduction of diarrhoea by probiotics was studied frequently, because diarrhoea is the main problem of piglets during the first weeks after weaning with utmost importance for production Simon et al (2003).

Table 3. Incidence of diarrhoea in piglets fed probiotic supplemented feed. (Effects compared to control group) Simon et al (2003)

Probiotic	Age	Incidence of diarrhoea	Statistical significance	Literature
B. cereus	8 weeks	Reduced	+	Kyriakis et al (1999)
B. cereus	Day 1-85	Reduced	+	Iben & Leibetseder (1989)
B. cereus	Day 7-21	Reduced	+	Zani et al (1998)
B. cereus	Day 24-66	No effect	-	Eidelsburger et al (1992)
B. cereus	25 kg live weight	No effect	-	Kirchgessner et al (1993)
B. cereus	2 weeks post weaning	Reduced	+	Jadamus (2001)
E. faecium	Day 1-70	Reduced	+	Männer & Spieler (1997)
E. faecium	8 Day before/after weaning	Reduced	+	Schumm et al (1990)
P. acidilactici	Day 5-28	Reduced	+	Durst et al (1998)
P. acidilactici *S. cerevisiae*	Day 5-28	Reduced	+	Durst et al (1998)

With regard to the evaluation of animal performance, the same conclusion can be draw for experiments with fattening chicken Simon et al (2001). This is also reflected by a series of experiments with turkey poultry under field conditions using three probiotics Männer et al (2002). Again none of the effects in performance were significant, on average weight gain was improved by 1,5% (+0,1 to + 3,8) and feed conversion by –2% (-7 to –3,5). A further observation was a more pronounced effect of additive during weeks 1 to 5. However again no significance was seen in the period’s week 1 plus 2 and 3 to 5, respectively Simon et al (2003).

Simon et al (2003) concluded that the inconsistency of the effectiveness of a feed additive is of course not convenient, but on the other hand comprehensible for this type of feed additive. Probiotics do not act like essential nutrients in term of a clear dose response until the requirements are met. Due to the complexity of intestine, individual variations of animals to probiotic inclusion may be the rule and not the exception. Considering this concept the range between no effect and significant effects seem to be reasonable.

The morphological changes in the bovine intestine are more complex than in mammals or poultry and thus the potential benefits of probiotic supplementation may also be greater Wallace and Newbold (1992).

Huber (1997) summarized the effects of probiotic feeding to baby calves and next to greater feed intake and improved weight gain the reduction of diarrhea was one of the most prominent results observed. The reduction of pathogenic *Escherichia coli* O157:H7 has also been reported by administering a probiotic preparation containing *Streptococcus bovis, Lactobacillus gallinarum, Saccharomyces cerevisiae* as active ingredients, respectively Ohya et al (2000). In a feeding trial with two different probiotic preparations (*Enterococcus faecium, Bacillus cereus*), added to the milk replacer for calves (50 to 85 kg body weight), a non significant increase in live weight gain was observed, together with a significant decrease of the frekuency diarrhoea Simon et al (2001). Allthough in ruminants the addition of some bacterial additives and Aspergillus oryzae have been shown to have beneficial effects, all authorised microbial feed additives for dairy cattle and with one exception for cattle for fattening are *Saccharomyces cerevisiae* strain. The actual knowledge on their mode of action effectiveness was recently reviewed by Newbold (2003). Newbold concluded: “Research on microbial feed additives for ruminant is often frustrating, because responses are small and highly variable” and claimed that the situation will improve as progress is made in defining of action of these additives.

Prebiotics effect on performance

A number of studies have shown trends for improvements in growth performance, decrease in variation, mortality and morbidity or increased resistence to colonization by pathogens associated with feeding prebiotics to pigs Patterson and Burkholder (2003). Problems with this study showing statistical responses may include low replication, low environmental challenge, level of prebiotic fed, timing of feeding the prebiotic challenge or stress. Response to growth promotant antibiotics is greater when pigs are stressed and it seems logical that response to prebiotics would also be increased when pigs are stressed. Orban et al (1997b) have observed increased gain in heat stressed broilers fed an arabinogalactan prebiotic or STOC, but not in broilers raised under normal temperatures. Numerical improvements in performance may be economically important on farm.

Estrada et al (2001) fed early weaned pigs (18d) FOS for 21 days with two inoculations of *Bifidobacterium longum* in the foirst week. There was a numerical increase in gain and a significant improvement of feed efficiency in pigs fed the symbiotic combination. Orban et al (1997a) observed numerical increases in performance of weanling pigs fed either STOC or an antibiotic in 2 trials. Antibiotic response was numerically higher than STOC response in this studie, but neither was significantly greater than the control. Russell et al (1998) observed numerical increases in average daily gain (ADG) in weanling pigs fed FOS or Carbadox. ADG increased from 0.35 to 0.40 and 0.36 kg/day in one trial and from 0.33 to 0.40 and 0.40 kg/day in a second trial for control, FOS and Carbadox treatments respectively. He et al (2002) examined the effect of supplementing FOS in the water or feed compared to the control and antibiotic treatments. Although none of the treatments were statistically significant, ADG was 0.33, 0.36, 0.36 and 0.38 kg/day for control, FOS in the water, FOS in the feed, and antibiotic, respectively. Patterson and Burkholder (2003) conclude: It is important to note that in studies where growth promotant antibiotics were provided as a positive control generally only numerical increases in performance were observed for the growth promotant antibiotic treatments.

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