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Review Article

The use of *Lactobacillus* as an alternative of antibiotic growth promoters in pigs: A review

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ABSTRACT

Antibiotics often supplemented in feed, used as a growth promoter may cause their residual effect in animal produce and also trigger antibiotic resistance in bacteria, which is of serious concern among swine farming entrepreneurs. As an alternative, supplementing probiotics gained interest in recent years. *Lactobacillus* being most commonly used probiotic agent which improves growth performance, feed conversion efficiency, nutrient utilization, intestinal microbiota, gut health and regulate immune system in pigs. The characteristics of *Lactobacillus* spp. and their probiotic effects in swine production are reviewed here under.

1. Introduction

Various stress factors including nutritional, environmental and weaning etc. at different stages of life affect the animal productivity and health. Weaning stress in piglets being the major cause for economic loss to pig farmers (Wilson et al., 1989). As the weaned piglets have limited digestive capacity, which triggers fermentation of undigested protein by opportunistic pathogens (mainly *Escherichia coli*, *Salmonella*) normally existing in gastrointestinal tract (GIT) which leads to production of branch chain fatty acids (BCFA) and ammonia nitrogen (Garcia et al., 2014). The BCFA and NH_3–N are the toxic metabolites to intestinal mucosa, which damage intestinal mucosa thereby ultimately results in diarrhea (Fuller, 1989; Jensen, 1998). This may usually causes a reduction in villous height and digestive enzyme activity for the first few days after weaning (Pluske et al., 1995). The common practice of supplementing antibiotics in livestock for improved animal performance was condemned due to its adverse effects on animal as well as human, the ultimate consumer of the animal produce. Since then, it has been the greatest challenge to farmers to rear healthy piglets devoid of antibiotics supplementation. However, these stress factors in livestock sector need to be addressed for profitable livestock farming.

In this scenario, latest reports indicate probiotic supplementation in swine seems to be better alternative for antibiotic use addressing the safe animal produce as well as to combat economic losses in pig farming. The term “Probiotics” is derived from a Greek word ‘biotikos’ meaning ‘for live’, which was first coined by Parker (1974) and define as the live microorganisms, when they were administered in adequate amounts, confer a health benefits on the host (FAO/WHO, 2002). At present, probiotics are classified by the US Food and Drug Administration as generally recognized as safe (GRAS) ingredients. Among various probiotic bacteria, *Lactobacillus* is most commonly used probiotic agent (McCony and Gilliland, 2007). *Lactobacilli* are gram-positive, non-motile, non-spore forming, acid-tolerant, non-respiring rod shaped (bacillus), or spherical (coccus) bacteria which produce lactic acids as the major metabolic end-product of carbohydrate fermentation (Cho et al., 2009). In farm animal they confer good intestinal health by stimulating the growth of a healthy microbiota (Walter et al., 2008), preventing intestinal colonization of enteric pathogens (Huang et al., 2004; Lee et al., 2012), reduced faecal noxious gas emission (Hong et al., 2002), production of antimicrobial substances, antibiotic resistance patterns, improving digestive ability and antibody mediated

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immune response, and demonstrable efficacy and safety (Wang et al., 2012; Hou et al., 2015). Probiotics are generally host-species specific (Dunne et al., 1999) and believed to be more effective in its natural habitat i.e., target species (Kailasapathy and Chin, 2000). However, selection of probiotic microbes is one of the most important criteria to get a positive response. The objective of this paper is to enlighten the efficacy of various *Lactobacillus* spp. as probiotic in swine production.

2. Microorganism commonly used as probiotics

The microorganisms commonly used as probiotics in livestock are presented in Table 1. The genus *Lactobacillus* has been reported as one of the major bacterial groups found in GIT (Dibner and Richards, 2005). Till now, no report was found on safety concerns related to *Lactobacilli* in animals. The genera *Bifidobacteria* is found to be inhabitant of GIT of both animals and humans, which helps in maintaining microbial balance in the GIT by reducing the harmful pathogenic microbes thereby, associated with good health status of the host (Huang et al., 2004). The genus *Enterococcus* belongs to the lactic acid bacteria (LAB) group and found naturally in food products, which are normal commensals of human and animal. *Enterococcus faecium* is the most common in the animal GIT, while in human *E. faecium* and *E. faecalis* are prevalent (Fisher and Phillip, 2009). These three species of *Enterococcus* are commonly used probiotics in animal/livestock feeding.

Bacillus are Gram-positive, spores-forming microorganisms, commonly associated with soil, water and air, and present in the intestinal tract due to involuntary ingestion of contaminated feed. Though some of the Bacillus species are used as a probiotic, speculation exists for their ability to produce toxins (Gaggia et al., 2010). The yeasts are also comprised as a residual microbial system of the intestinal microbiome where *Saccharomyces cerevisiae* is widely present in the nature and used in food and beverage industry for its fermentation properties. It is also used as a probiotic especially in ruminants and pig feeding (Kumar et al., 2012).

Table 1
Different groups of lactic acid bacteria commonly used as probiotics in swine production.[a]

Genus	Species
Lactobacillus	*L. acidophilus*
	L. casei
	L. delbrueckii sub sp. *bulgaricus*
	L. brevis
	L. cellobiosus
	L. curvatus
	L. fermentum
	L. plantarum
	L. reuteri
	L. salivarius sub sp. *thermophilus*
	L. gasseri
Lactococus	*L. cremoris*
	L. lactis
Pediococcus	*P. acidilactici*
	P. pentosaceus subsp. *pentosaceous*
Bifidobacterium	*B. bifidum*
	B. adolescentis
	B. animalis
	B. infantis
	B. longum
	B. pseudolongum
	B. thermophilum
Enterococcus	*E. faecium*
Bacillus	*subtilis*
	coagulans
	cereus
	licheniformis
Yeast	*Saccharomyces cerevisiae*
	Aspergillus oryzae

[a] Source: Dunne et al., 2001; Sekhon and Jairath, 2010

3. Mode of action of *Lactobacilli* as probiotic

Lactobacilli stimulate rapid growth of beneficial microbiota in the GIT which become abundant and induce competitive exclusion of pathogenic bacteria either by occupying binding sites on intestinal mucosa or competing for nutrients and absorption sites with pathogenic bacteria (Malago and Koninkx, 2011; Zhao and Kim, 2015); by rapid utilization of energy source which may reduce the log phase of bacterial growth. Most of the enteric pathogens adhere to the intestinal epithelium through colonization thereby develop diseases (Walker, 2000). Consequently, the probiotic lactobacilli have the ability to adhere the gut epithelium and thus compete with pathogens for adhesion receptors i.e., glycol-conjugates (Umesaki et al., 1997). Probiotic bacteria produce organic acids, hydrogen peroxide, lactoferrin and bacteriocin which may exhibit either bactericidal or bacteriostatic properties (Jin et al., 1997; Pringsulaka et al., 2015). *Lactobacillus* have proven to be capable of acting as immune-modulators by enhancing macrophage activity (Perdigon et al., 1986), increasing the local antibody levels (Yasui et al., 1989), inducing the production of interferon (De Simone et al., 1986) and activating killer cells (Kato et al., 1984). They prevent the proliferation of coliform bacteria thus amine production diminishes which produced due to decarboxylation of amino acids by coliform bacteria.

4. Selection of lactobacilli for feeding as probiotics

The followings are the criteria that can be used for the selection of microbial strains as probiotics.

1) Resistance to *in vitro/in vivo* conditions: they should be resistant to acidic pH and bile salt. After administration, the microbes should not be killed by the defense mechanisms of the host and should be resistant to the specific conditions occurring in the body.
2) Origin of the strain: Probiotics are generally host-species specific (Dunne et al., 1999). It is believed that probiotic organism is more effective if it is naturally occurring in the target species (Kailasapathy and Chin, 2000). The strains should be properly isolated and identified before use.
3) Biosafety: *Lactobacillus*, *Bifidobacteria* and *Enterococcus* are the microbes which fall in the category of generally recognized as safe (GRAS) and are most widely used microorganisms as probiotics.
4) Viability/survivability and resistance during processing (e.g., heat tolerance or storage): Thermophilic/thermo-tolerant organisms have an advantage as they withstand higher temperature during processing and storage.

However, other criteria might also be considered for selection of mono or multi strains bacteria as probiotics like as probiotic-symbiotic interaction, stimulation of healthy microbiota and suppression of harmful bacteria. Adopting these predetermined criteria, it could be possible to select the best strains of probiotics which could be effective therapeutically and nutritionally.

5. Mode of feeding probiotics

Mode of feeding probiotic affects the response of animal to the probiotic feeding. Generally cultures are fed either in form of lyophilized powder or live cells. When a lyophilized culture fed to

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