Journal of Applied Pharmaceutical Science Vol. 3 (07), pp. 174-178, July, 2013
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2013.3733
ISSN 2231-3354

Potential non-antibiotic growth promoting dietary supplements for animal nutrition: A Review

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ARTICLE INFO

Article history:
Received on: 14/06/2013
Revised on: 30/06/2013
Accepted on: 26/07/2013
Available online: 06/08/2013

Key words:
Feed supplements, Growth promoters

ABSTRACT

The present article stresses on the effect of natural growth promoters dietary organic acid (OA) supplements and mannan oligosaccharide (MOS) and xylanase as animal feed supplement on live body weight gain, dressing percentage, weight of vital organs and muscles and mean villus lengths in digestive tract of livestock along with their application as growth promoters in commercial animal feed.

INTRODUCTION

The present article envisage on the use of organic acid (OA) salts, mannan oligosaccharide (MOS) and xylanase which can be used as potent natural growth promoters in livestock feed. Many research works are being carried out in this aspect to standardize non-traditional growth promoters (*viz.*, OA salts, MOS and xylanase) which can effectively replace commercially available costly antibiotic growth promoters and can also be put to use as prebiotic (Ganguly and Mukhopadhayay, 2012). Even the dietary prebiotics in commercial fish feed have proved useful for commercial aquaculture practices though out the globe (Ganguly *et al.,* 2013a,b,c). It is a potential area of research and further work is in demand. In livestock production organic acids are mainly used in order to sanitize the feed having salmonella infection (Hinton *et al.,* 1985; Barchieri and Barrow, 1996; Thompson and Hilton, 1997). Organic acids (OA) in their undissociated forms are able to pass through the cell membrane of the bacteria, where they dissociate to produce H^+ ions which lower the pH of bacterial cell causing the organism to use its energy to restore the normal balance. Whereas the $RCOO^-$ ions, produced from the acid can disrupt DNA, hampering protein synthesis and putting the organism in stress. As a result the organism cannot multiply rapidly (Nursey, 1997). Prebiotics are non-digestible feed ingredients that beneficially affect the host by selectively stimulating the growth or activity of one or a limited number of bacterial species, already resident in colon and thus attempt to improve host health (Gibson and Roberfroid, 1995).

Mainly prebiotics are small fragments of carbohydrates and commercially available as oligosaccharides of galactose, fructose or mannose (Ganguly *et al.,* 2010; 2013b,c). Among these, mannan oligosaccharide obtained from *saccharomyces spp.* of yeast outer cell wall maintain gut health by immunomodulation (Paul *et al.,* 2013) and by adsorption of pathogenic bacteria containing type-I fimbriae or by agglutinating different bacterial strains (Spring *et al.,* 2000) and increase villi length uniformity & integrity (Loddi *et al.,* 2004).

Effects of buffered propionic acid in presence and absence of bacitracin or roxarsone were reported earlier (Izat *et al.,* 1990) in which significant increase in dressing percentage for female broilers and a significant reduction in abdominal fat of males at 49 days (Versteegh and Jongbloed, 1999) tested the effect of dietary lactic acid on performance of broilers from 0 to 6 weeks age. Body weight gain tended to be greater, whereas feed to gain rations were significantly improved where birds were fed 2% lactic acid as prebiotic.

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Beneficial effects of different organic acids like formic acid, propionic acid, lactic acid ammonium formate and calcium propionate etc. as growth promoter and prebiotic have been studied earlier for having substitute to antibiotic (Ganguly *et al.,* 2010; Ganguly and Mukhopadhayay, 2012).

Xylanase is the name given to a class of enzymes which degrades the linear polysaccharide beta-1, 4 xylan to xylose, thus breaking down hemicelluloses which are a major component of the cell wall of the plants. Xylanases are known to increase protein digestibility of wheat and this is attributed particularly to release of protein from the xylan enriched aleurone layer. Xylanase supplementation improves conjugated bile acid function in intestinal contents and increase villus size of small intestine wall in broiler (Bar *et al.,* 2012; Ganguly, 2013b,c). Supplementing broiler diets with combination of xylanase and β-glucanase improves the nutritive value of the diet (Veldman and Vahl, 1994). The addition of Xylanase improves weight gain, feed intake, feed efficiency, AME and decreased water intake (Wu *et al.,* 2004) and Vitamin E content of liver in broiler was significantly improved by addition of xylanase (Danicke *et al.,* 1999; 2001). Nutri-xylanase is a bacterial xylanase processed from *Bacillus subtilis* and produced by a micro-filtration advanced fermentation technique.

The plant derived and herbal growth promoters supplemented in the diet or added in the drinking water in the broiler and poultry birds have a promising biological effect on their growth performance, to reduce the pathogenic bacteriological load in different parts of digestive tract and to increase villus height in different segments of small intestine mainly in duodenum. The plant derived growth promoter enhance productive performance of the broiler in terms of body weight gain with minimum alteration of gut morphology and the possibility of bacterial invasion can be regulated (Ganguly, 2013b;c).

Effect on live body weight gain

Mairoka et al (2004) reported that mixture of organic acids, as a substituted of AGPs improved the performance of birds even in absence of antibiotic. Savage et al (1997) concluded from a dose responsive study (0-0.33%) that MOS @ 0.11%, maximized weight gain in animals up to 0-8 weeks of age. Stanley et al (2000) found same type of effect with supplementation of 0.1% MOS on hybrid Tom's body weight gain. Eidelsburger and Kirchgessner (1994) reported that calcium formate alone or in combination with other acids when given at the rate of 0.5% and 1.5%, increased FCR and growth performance in broiler chickens up to 35 days of age. Benedetto (2003) also observed mix of organic acids (ACIDLAC) used as a replacer of AGPs and improved production performance in breeding hens along with other beneficial effects. Parks et al (2001) reported from a study from turkeys supplemented with MOS that MOS may be utilized as a alternative to AGPs to improve turkey performance.

It has also been reported that formic acid and propionic acid mixture (85% and 15%) added at 1% level to the broiler chicken ration in the initial period did not affect weight gain (Visek, 1978). Reports have also been made about significant increased in body weight gain with the supplementation of 0.5% lactic acid in drinking water (Veeramani *et al.,* 2003). The mix of organic acids improves performance of birds (Maiorka *et al.,* 2004). From a dose responsive study, it was concluded (0-0.33%) that MOS @ 0.11%, maximized weight gain in animals up to 0-8 weeks of age. The same type of effect was found with supplementation of 0.1% MOS on hybrid Tom's body weight gain (Parks *et al.,* 2001) conducted in turkeys supplemented with MOS that MOS may be utilized as a alternative to AGPs to improve turkey performance (Podolsky, 1995; Pelicano, 2003). It has already been reported that 1% formic acid or 1.45% calcium formate did not affect live weight of broiler chicken (Izat *et al.,* 1990). It was found out that 80% formic acid and 20% propionic acid mixture added at 1% level to broiler chicken ration did not affect live weight (Kaniawati *et al.,* 1992). It was also revealed that increased in body weight with supplementation of lactic acid.

A series of experiments was conducted by Paul et al. (2013b) to evaluate the various aspects and effects of different combination of organic acids *viz*., formic acid and propionic acid as a replacer of growth promoter antibiotic(s) in ducks. The ducks were divided into five equal groups with one as Control. Studies on body weight gain revealed that after 48 weeks body weight gain was higher in treated groups as compared to the control Group C (control).

Effect on dressing percentage and weight of vital organs and muscles

It has been reported that higher villus height in the ileum with the diet based on organic acidifier compared with diet fed without MOS + organic acidifier (Savage *et al.,* 1997). Dressing percentage and weight of different organs and muscles at 21 and 42 days there was no major influence on the dressing percentage, organ and muscle weight under different treatment groups with organic acid salts individually and its combination in broiler birds. These findings in line of earlier report (Pelicano, 2005). Higher villus height in duodenum, jejunum in small intestine was reported with most organic acidifier in diet of broiler (Loddi *et al.,* 2004). The supplementation of organic acidifier may increase villus height of different parts of small intestine. So, organic acidifier reduces the growth of many pathogenic and non-pathogenic intestinal bacteria, decreases intestinal colonization and reduces infections process, ultimately decreasing inflammatory process at the intestinal mucosa. It increases villus height and function of secretion, digestion and absorption of nutrients can be appropriately performed by the mucosa (Iji and Tivey 1998). The positive effects of the use of prebiotics on the intestinal mucosa with significant increase in villus height of three segments of small intestine of birds supplemented with MOS is also reported (Maiorka *et al.,* 2004).

Silverslides and Bedford (1999) and Bar et al (2012) showed xylanase supplementation had a positive body weight gain and the feed to gain ration. Danicke et al (2001) found addition of xylanase significantly increased the weight gain up to 21 days of age and decreased the feed to gain ratio slightly. Mathlouthi et al

(2003) showed feed efficacy and body weight gain was improved with the supplementation of xylanase. Wu et al (2004) observed that the xylanase supplementation significantly improved weight gain, feed efficiency and AME. Wu et al (2004) observed that addition of xylanase and phytase reduced the relative weight gain of the small intestine by 15.5% and 11.4% respectively. Yubo et al (2005) reported body weight and feed per gain ratio was improved ($P<0.05$) by xylanase supplementation in the first 2-3 weeks in broilers.

Ahmad et al (2007) noticed xylanase supplementation increased body weight, feed intake and feed gain ratio. Liu et al (2007) observed xylanase supplementation increased body weight gain from 0-21days of age of broilers. Gao et al (2008) found that the supplementation of xylanase enzyme improved ($P<0.05$) growth performance and feed conversion efficiency (FCE). Mannio (1981) reported that the body weight gain was improved by 12 to 25% and feed consumption was increased by 3 to 21% when chicks at 4 weeks of age fed diets supplemented with enzyme like xylanase. Veldman and Vahl (1994) noticed xylanase supplementation improved food conversion ratio by 2.2-2.9% and body weight gain by 0.2-2.5%.

Effect on increase in villi length

Das et al (2012) reported that MOS (mannan oligosaccharide) and organic acid treated groups of Japanese quails (*Coturnix Coturnix Japonica*) produced consistently higher villi length in treated birds and MOS in poultry feed can be used as alternatives to the antimicrobial and antibiotic growth promoters and can be used to achieve good health for sustainable and economic poultry production. On the other hand, experimental studies were conducted by Roy et al (2012) to evaluate the pathomorphological effect of different combination of organic acids *viz.*, formic acid, propionic acid and lactic acid as a replacer of growth promoter antibiotics in poultry birds. The birds were divided into six equal groups of negative control (C1), positive control (C2) and four treatment groups. Birds of group C1 were supplied with diet without any antibiotics or acid, group C2 with Virginiamycin @ 500 gm/100kg feed, group T1 with 0.3% ammonium formate group T2 with 0.3% calcium propionate, group T3 with 0.15% ammonium formate and 0.15% calcium propionate and group T4 with 0.1% ammonium formate, 0.1% calcium propionate and 0.1% calcium lactate. Body weight gain was higher in C1 and C2 compared with treatment groups in first two weeks, but pathological changes were maximum in negative control, i.e. after 6 weeks, weight gain was significantly better in T3 and T4 than in groups C1, T1 and T2 groups. Bacteriologically, significant ($P<0.01$) reduction of *E. coli* in T1 and T4 was evident. Pathomorphological changes in group C1 and T2 were maximum. Group C2 and T1 showed same types of changes but the changes were less severe in group T3 and T4. The most common changes among the groups were thickening of muscular layer, accumulation of inflammatory cells and congested blood vessels. Based on present investigation, it is suggested that combination of organic acid may be used in broiler feed as a replacer of growth promoter antibiotic instead of using only one acid. Pelicano et al (2005) observed higher villi length in ileal region when birds were fed with prebiotic based on MOS, compared to the control group. Loddi (2003) described higher villi in the intestinal mucosa (duodenum) of birds fed with MOS at 7 and 21 days of age respectively.

Pelicano et al (2005) reported that in jejunum MOS + OA resulted in significantly higher villi in the jejunum ($p<0.01$) followed by the diets containing MOS based prebiotics. Microorganisms that is sensitive to acid pH and results in higher villi length (Radecki and Yokoyama, 1991). Some bacteria may recognize binding sites on the prebiotics instead of intestinal mucosa and the colonization by pathogenic bacteria in intestine is thus reduced. Therefore, besides a lower infection incidence, there is an increase in the absorption of available nutrients, a mechanism that directly affects the recovery of the intestinal mucosa, increasing villi length. These results disagree to those obtained by Pelicano et al (2003) and Santin et al (2001) respectively, who found no difference in ileal villi length with the use of probiotics and prebiotics.

Effect on gut microbial load

The findings of Newman (1994), Lon (1995), Spring et al (2000) and Fairchild et al (2001) proved that MOS and OA successfully reduces bacterial load in the intestine of broiler birds. Sims et al (2004) also found that MOS + BMD treated turkeys showed significantly lower *Clostridium perfringens* population in the gut than control at 6 weeks of age. MOS is believed to block type-I fimbriae and prevents pathogens from attaching to the intestinal lining and passes them out of the gut. (Dawson and Pirulescu, 1999). Stanley et al (2004) concluded that yeast cell culture residue (YCR) treated broiler chicks resulted lower intestinal Coliform population in comparison to control and other antibiotic treated (lasalocid @ 90.7kg/ton, bacitracin @50gm/ton) groups. For this reason MOS treated birds showed lens microbial load in the gut.

Bacteriological studies of different portions of small intestine revealed that total coliform count and *Clostridium perfringens* count (log_{10} CFU/g) was significantly ($P<0.05$) reduced in the small intestine of the birds in treated groups as compared to Group C. Salmonella sp. was not found in any group. No significant results of Lactobacillus count (log_{10} CFU/g) were noticed in the intestinal digesta of the ducks in treated groups. Study on villus height of different potions of small intestine (i.e. duodenum, jejunum and ileum) revealed significantly higher villus height in treated groups as compared to Group C (control) (Paul *et al.*, 2013b).

Hrangkhawl et al. (2013) conducted series of experiments to study the effect of mannan oligosaccharide and dietary organic acid supplements on body weight of broiler birds. The present investigation showed better growth performance in combination with organic acid salts in terms of body weight. It was found that mean villus length increased significantly ($P<0.01$) in the treatment groups rather than the control birds.

CONCLUSION

The organic acid salts and MOS can be used as alternatives to growth promoters but their combination strategy can be used to achieve good health and growth performance. The live body weight gain is better in organic acid and MOS supplemented animals. MOS and organic acids individually or in combination reduce gut microbial load and improve growth performance of animals.

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How to cite this article:

Subha Ganguly., Potential non-antibiotic growth promoting dietary supplements for animal nutrition: A Review. J App Pharm Sci. 2013; 3 (07): 174-178.