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APPLICATION OF PREBIOTICS AS FEED ADDITIVES IN POULTRY NUTRITION-A REVIEW

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ABSTRACT: Since the EU banned antibiotic growth promoters (AGPs) in poultry nutrition, many researches has been conducted to explore the use of possible effective substitutes. Prebiotic products are incorporated in poultry feed to replace AGPs in order to stimulate or promote the effective use of feed nutrients which may subsequently result in more higher production rates and improved feed efficiency and induce the growth and activity of beneficial microorganism. Moreover, prebiotic may improve digestion and stimulate the immune system in poultry. Consequently, several researches were performed to confirm their beneficial qualities. Productive performance that were dominantly observed and analyzed are feed intake, body weight gain and feed conversion ratio. Most of the trials showed slight positive effects, however significant results were rare. Since there are almost unlimited possibilities concerning dosage and products of prebiotic there is still more research needed. Therefore, it is necessary to define and declare the composition of prebiotic used in experiments. Generally, it can be stated that prebiotic have the potential to be considered as an alternative to AGPs in poultry nutrition. Nevertheless, there is still further research under more standardized condition needed to evaluate the right dosage and the exact mechanism of actions.

Keyword: Prebiotic -Productive - Nutrient digestibility - Microbial populations-Poultry

INTRODUCTION

Many research have been conducted to define and explore the importance of using prebiotics. Various types of oligosaccharides, including inulin, fructooligosaccharides (FOS), galactooligosaccharides (GOS), soya-oligosaccharides (SOS), xylo-oligosaccharides (XOS), pyrodextrins, isomalto-oligosaccharides (IMO), lactulose and mannanoligosaccharide (MOS) are commonly considered as prebiotics (Alloui et al., 2013). Prebiotics are a general term to refer to chemicals that induce the growth or activity of microorganisms (e.g., bacteria and fungi) that contribute to the well-being of their host (Schloss, 2014). The most common example is in the gastrointestinal tract, where prebiotics can alter the composition of organisms in the gut microbiome and it is defined as “a nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon (Roberfroid, 2007). Roberfroid (2007) stated that only two particular prebiotics then fully met this definition: trans-galactooligosaccharide and inulin Moreover, Coxam (2007) reported that prebiotic should increase the number or activity of bifidobacteria and lactic acid bacteria, the importance of the bifidobacteria.

The lactic acid bacteria may have several beneficial effects on the host, especially in terms of improving digestion including enhancing mineral absorption, and the effectiveness and intrinsic strength of the immune system (Seifert and Watzl, 2007). The immediate addition of substantial quantities of prebiotics to the diet may result in an increase in fermentation, leading to increased gas production, bloating or bowel movement (Marteau and Seksi, 2004). Until bacterial flora are gradually established to rehabilitate or restore intestinal bacteria, nutrient absorption may be impaired and colonic transit time temporarily increased with an immediate addition of higher prebiotic intake (Marteau and Seksik, 2004).

In some studies the ability of prebiotic to be used as alternative feed additive has already been proven and thus started to play a decisive role in nutrition of poultry. The benefits of MOS are based on specific properties, including modification of the intestinal micro-flora, reduction in turnover rate of the intestinal mucosa, and modulation of the immune system in the intestinal lumen, these properties have the potential to enhance growth rate, feed efficiency, and livability in poultry species (Parks et al., 2001). Nevertheless, the uses of prebiotics in diets for poultry have been shown improvement in bird’s immunity and increasing performance. In some studies the ability of prebiotic to be used as alternative growth promoters has already been proven and thus started to play a decisive role in nutrition of poultry. Anyhow, only limited research is available, which handicaps full comprehension of physiological responses. Therefore, the purpose of this study is to give an overview on the definition of prebiotics as feed additives ingredients, its composition and mode of action, as well as on the use of these prebiotic ingredients in poultry diets with particular attention on the effects of prebiotics on performance characteristics, nutrient digestibility, carcass criteria, and intestinal microflora.

Prebiotic components mode of action

Prebiotics defined as a nondigestible food that is used as an energy source by beneficial bacteria found naturally in the body's intestines much of the interest in prebiotics is focused on nondigestible fibers found in plants, mainly oligosaccharides such as inulin type fructooligosaccharides (FOS), mannanoligosaccharide (MOS) and trans-galactooligosaccharides (TOS) (Roberfroid, 2007). Prebiotics may have beneficial effects on the animal's physiology by selectively stimulating beneficial microbiota in the digestion system. This may have beneficial effects in reducing the incidence of enteric pathogens. Competitive exclusion of pathogens by increasing numbers of microbiota that are associated with a healthy host can produce a variety of bacteriocins that have a detrimental effect on the pathogen by promotion of macrophages, stimulation of antibody production, and antitumour effects (Vamanu and Vamanu, 2010). Prebiotics may be able to have directly effect on the pathogen or on the host in a microbiota-independent manner. Another mode of action is ability and adhering competition of represents colonization in the intestinal mucous membranes to prevent adhesion and invasion of pathogens and, which is a key performance parameter, inhibition of their colonization and replacement of already adhered ones (Patterson and Burkholder, 2003).

There is evidence that the principal mechanisms of prebiotics is immunomodulation, that includes selective growth of lactic acid-producing bacteria, resulting in an increasing in the concentration of short chain fatty acids (SCFA) like propionate, acetate, and especially butyrate which is the preferred energy source of colon oocytes and stimulates gut integrity (Alloui et al., 2013). High fermentation activity and high concentration of the SCFA is correlated with a lower pH, which is associated with a suppression of pathogens and increased solubility of certain nutrients (Józefiak et al., 2004). Fermentation products such as SCFA increase after prebiotic supplementation as a result of oligosaccharide fermentation by resident microbiota. Short chain fatty acids (SCFA) production is an important physiological process of colonic microorganisms and may be useful in improving gastrointestinal health by reducing the occurrence of diarrhoea through modulating the microbiota (Macfarlane et al., 2008). This phenomenon may inhibit some pathogenic bacteria and reduce colonization of some species like Salmonella and Campylobacter (Charalampopolus and Rastall, 2009). Supplementary dietary MOS improves animal resistance to enteric disease and promotes growth by prevent colonization of enteric pathogens, inhibiting bacterial adhesion to gut lining, improves the brush border mucin barrier, changes microflora fermentation to favour nutrient availability for the host, improves immunity, enhances the unity of the gut lining and brings down enterocyte turnover rate (Ferket, 2003).

Effects of prebiotics on productive performance

Several studies have been conducted to explore the effect of prebiotic on poultry performance (Table 1). Toghyani et al. (2011) found that adding 1 mg/kg mannanoligosaccharide (MOS) in broiler chicks diets results in significantly ($P<0.05$) higher feed intake and body weight over 14-28 d and overall period compared to control chicks. Feed efficiency and productive performance of birds receiving the supplementation of prebiotic improved over different periods in comparison to control birds (Spring et al., 2000). The feed conversion ratio describes the relation of feed intake and body weight gain. More precisely, it is the animals overall efficiency in converting feed mass into body mass over a specific period of time. Konca et al. (2009) found that 1 mg/kg mannan oligosaccharide increased feed intake and feed conversion ratio significantly (P<0.05) in turkey during 10 to 20 weeks of age. Also, Sohail et al. (2012) demonstrated that adding MOS to broiler chicks diet had gave higher (P<0.05) body gain, feed intake and better feed conversion ratio compared with the control group under heat stress. Abdel-Raheem et al. (2011) reported that 2 g/kg mannan-Oligosaccharide (MOS) in the starter diets and 0.5 g/kg of the grower diets had increased feed intake and body weight as well as reduced mortility rate of broiler chickens. Abdel-Wareth, (2016) found that supplementation of symbiotic to laying hens diet improved feed intake and productive efficiency. Furthermore Murshed et al. (2015) found that used (Techno Mos) at 0.75 g/kg in starter diet and 0.6 g/kg in the finisher diet had improvements in body weight and body gain of broiler chickens. Also Wang and Zhou, (2007) reported that using of prebiotics (mannose oligosaccharides at 3000 mg/kg at age of 0 to 2 weeks and 2500 mg/kg at 3 to 7 weeks, significantly increased body weight gain, feed intake and improved feed efficiency than the non-supplemented group. Likewise, dietary supplementation of probiotics and prebiotics improved body weight gain and feed conversion ratio of broilers at 28 days of age (Yun et al., 2017). Awad et al. (2009) reported that a mixture of probiotics and prebiotics products had comparable potential to improve broiler performance as an avilamycin treatment. In addition, supplemental inulin at 10 g/kg diet improved body weight gain and feed efficiency of female chickens (Yusrizal and Chen, 2003). Productive performance in broilers has been evaluated with addition of prebiotic. Body weight, feed intake and feed conversion ratio were reported to improve in the majority of studies (Zduńczyk et al., 2005; Yang et al., 2008; Baurhoo et al., 2007). In comparison with the control group, dietary supplementation with 100 mg/kg of chito-oligosaccharide improved the growth of broilers during both the starter and grower periods as well as over the entire experimental period (Li et al., 2007).

On the other hand many researchers found that supplementation of prebiotic did not affect productive performance (Midilli et al., 2008; Yalcınkaya et al., 2008). Also the dietary MOS supplementation did not affect (P>0.05) body weight and body gain (Waldroup et al., 2003; Yalcınkaya et al., 2008). Rehman et al. (2008) observed that inulin at 1g/ kg diet had no effect on the final BW of broilers. Also, Alzueta et al. (2010) showed that the addition of inulin (from 5 to 20 g/kg) to a maize-soybean meal based diet did not improve the growth performance of broiler chickens. In harmony with these results, mortality was non-significant (P>0.05) by adding MOS at 21 days of age (Gao et al., 2008). Furthermore Murshed et al. (2015) found that used (Techno Mos) at 0.75 g/kg in starter diet and 0.6 g/kg in the finisher diet did not influenced feed intake of broiler chickens.

The variations in results of previous studies could be due to feed intake and body gain depend on several factors like genotype, housing, hygienic conditions, management, feeding system and diet attributes. Also this is due to the lack of standardization in varying parts of experimental research. Nevertheless it has to be kept in mind that there is still insufficient significant evidence on prebiotic as natural growth promoters on ducks.

Effects of prebiotics on nutrients digestibility

Beneficial effects of prebiotic on nutrient digestibility of poultry are reported only rarely (Table 2). Alzueta et al. (2010) showed that inulin supplementation improved the digestibility of protein and fat in a maize-soybean meal based diet, but had no effect on the performance of broiler chickens. Boilers fed prebiotics-based diets had improved dry matter digestibility compared with control group (Yun et al., 2017). The nutrient digestibility of dry matter was improved by feed additives of probiotics in broilers (Apata, 2008). Likewise, Mountzouris et al. (2010) found that supplementation of 108 CFU/g probiotics/kg increased dry matter digestibility in broilers. These results infer that dry matter digestibility was improved due to an increase in the beneficial microorganism, such as Lactobacillus. Moreover, the prebiotic induce changes in the intestinal mucosal structure (Rehman et al., 2007) and to improve gut health (Roberfroid, 2005). Compared with the birds in the control, the birds receiving 100 mg/kg of chito-oligosaccharide had better nutrient digestibility of dry matter, crude protein, energy, calcium, and phosphorus (Liet al., 2007). Supplementation of chito-oligosaccharide improved gut health and thus increased nutrient digestibility in broilers (Huang et al., 2005). Tuohy et al. (2003) reported that supplementation of oligosaccharide to broiler diet improved the nutrient digestibility as was due to an improvement in gut health. Wang et al. (2005) also reported that dietary supplementation of 125 mg/kg of chito-oligosaccharide improved nutrient digestibility by improving gut health.

The beneficial effects of prebiotic on nutrient digestibility might be related to some of the effects attributable to prebiotics, particularly their ability to induce beneficial changes in the intestinal microflora and to improve gut health (Alzueta et al., 2010). Supplementation of prebiotic to broiler chickens enhances the intestinal mucosal structure, including increase in the length of villi (Rehman et al., 2007). On the other hand, Biggs et al. (2007) who reported that supplementation of inulin to broiler diets at 8 g/kg diet depressed amino acid digestibility but that no deleterious effect was found at a lower concentration (4 g/kg). Fructo-oligosaccharide supplementation at 20g/kg to male pigeon’s diet had no significant effects on nutrient digestability (Janssens et al., 2004). Ratriyanto et al. (2009) reported that used supplementation of inulin at 2g/kg in piglet’s diet, did not affect the ileal digestibilities of dry matter, crude protein, ether extract and crude fiber. These apparent contradictions in the effectiveness of prebiotic when fed to birds may be related to prebiotic source used, dosages, type of diet, animal characteristics, hygiene, husbandry conditions and environmental stress (Patterson and Burkholder, 2003).

Effects of prebiotics on carcass criteria

Certain types of prebiotics have been used as feed additives to improve animal performance and enhance carcass criteria (Table 3, Owens and McCracken, 2007; Pelicano et al., 2004). Feeding prebiotic to broilers increased ($p<0.05$) the relative weight of gizzard and proventriculus, spleen, bursa of fabricius, and the two ceca (Abdel-Hafeez et al., 2017). Furthermore Abdel-Raheem et al. (2011) reported that there is a significant increase ($p<0.05$) in the carcass weight and dressing % as well as in the absolute weight of the immune organs (bursa and thymus), in prebiotic supplemented broilers group. These results were in harmony with those results of previous studies (Wang et al., 2003; Huang et al., 2007) However, Yang et al. (2007) reported that dietary MOS supplementation decreased intestine and liver weight in broilers. Mahmud et al. (2008) reported that addition of prebiotic (MOS) to birds diet had reduced abdominal fat percentage value compared to the birds fed the control diet. No clear mechanisms have been reported to be responsible for the reduction of lipid synthesis by prebiotics. It might in part be due to increasing beneficial bacteria such as Lactobacillus that increased the activity of acetyl-CoA carboxylase, which is the rate limiting enzyme in fatty acids synthesis (Abdel-Hafeez et al., 2017). On the other hand, Toghyani et al. (2011) found that carcass traits evaluated including liver, pancreas, gizzard, heart, small intestine and cecum weights, small intestine, and cecum lengths were not markedly affected by dietary supplementation of prebiotic treatments. Adding MOS on carcass had no significant effect on carcass and cut-part yields (breast, thigh, wing, liver, heart, gizzard, intestinal system or abdominal fat (Mahmud et al., 2008; Midilli et al., 2008; Konca et al., 2009). Supplementation of prebiotic had no significant effect on abdominal fat of broilers chickens (Waldroup et al., 2003; Bozkurt et al., 2005). Likewise, Wang and Zhou, (2007) observed that were no significant in carcass yield, internal organs and breast yield. Supplementation of prebiotic to broilers diets did not affect ($p>0.05$) the carcass yield, liver, heart, and small intestine (Abdel-Hafeez et al., 2017). Also, it was seen that the spleen weight did not show any significant effect between prebiotics (Awad et al., 2009). Midilli et al. (2008) who did not observe any significant impact of Mannan-oligosaccharides on carcass yield. The weight of gizzard, liver and bursa of fabricius did not show any significant difference ($P>0.05$) by supplementation of prebiotic (Odefemi, 2016). As far as the literature denotes, the effect of prebiotics as feed additives on carcass traits and meat quality still has not been well studied.

Effect of prebiotic on microbial populations

It is generally known that the beneficial gut bacteria play an important role in host metabolism, nutrient digestion, growth performance and health of the host poultry. Prebiotics are current strategies with great potential to modify and manipulate the gut microbiota. Effects of prebiotics on microbial populations of previous studies are presented in Table 4. Geier et al. (2008) who reported that MOS at 5 g/kg and FOS at 5 g/kg supplementation in Cobb 500 birds resulted in significant increase in ileal Lactobacillus profile. Prebiotics have been reported to beneficially affect the microbiota, improve nutrient utilization and enhance the immune system (Patterson and Burkholder, 2003; Biggs et al., 2007; Huang et al., 2007). A number of studies have demonstrated that dietary inclusion of MOS can increase intestinal numbers of beneficial bacteria such as lactobacilli and bifidobacteria, whilst decreasing E. coli (Baurhoo et al., 2007). Fernandez et al., 2002 demonstrated that MOS is effective in reducing Salmonella infection of birds. Baurhoo et al. (2007) found the addition of MOS significantly reduced E. coli counts in both litter and ceca samples in broilers.

Dietary MOS inhibits growth of intestinal pathogenic microorganisms through binding to cell walls of bacteria preventing the bacteria from attaching to intestinal epithelial cells (Spring et al., 2000). Choi et al. (1993) reported that FOS supplementation at the level of 0.22% increased bifidobacteria and lactobacilli and decreased C. perfringens and E. coli populations in the ileal content of broilers. Sims et al. (2004) showed that 6-wk-old turkeys in a MOS treatment group had significantly less C. perfringens in their large intestines than did the control birds. Fructo-oligosaccharide may help to control or reduce the growth of harmful bacteria such as C. perfringens (Hofacre et al., 2005). Baurhoo et al. (2007, 2009) reported an increase of lactobacilli and bifidobacteria in the ceca of broilers due to dietary MOS. While Spring et al. (2000) noted a decrease of Salmonella in the ceca of broilers, but no difference in lactobacilli, coliforms, enterococci, and anaerobic bacteria. However, Abdel-Raheem et al. (2012) reported that using MOS at 2 g/kg of the starter diets and 0.5 g/kg of the grower diets in chicks, failed to elicit any significant ($P>0.05$) effect on the total lactobacilli and E coli colony counts at day 21 in the different parts of the small intestine (duodenum, jejunum, ileum and cecum). Yang et al. (2007) have not seen any significant difference with supplementation of MOS in ceca microbiology populations. Bonos et al. (2010) used MOS by 1 g/kg and 2 g/ kg in two hundred twenty-five 1-day old Japanese quail diet, they reported that on day 21, there was a tendency ($P\leq0.100$) for group MOS 1 g to have a higher total aerobic bacteria count compared to group control, but there was no significant difference for the other bacterial populations. Ghosh et al. (2007) found no significant difference on coliforms or E. coli counts in the small intestine of quail, but a decrease of Clostridium perfringens. Sims et al. (2004) found no significant difference on lactobacilli, coliforms, and E. coli in turkeys fed MOS. Ratriyanto et al. (2009) used inulin alone by 0.2% in piglets diet, they reported that dietary supplementation with inulin to a piglet's diet did not affect ($P>0.05$) the concentration of various microbial metabolites both at the ileal and faecal level. It could be stated that adding prebiotic to poultry diets can improve health status of bird's gastrointestinal tract by reducing the harmful bacteria and increasing the beneficial bacteria.

CONCLUSION

Generally, it can be recommended that prebiotic components have the potential to be considered as an alternative to in feed-antibiotic and improving productive performance and health status of poultry. Nevertheless, there is still further research under standardized conditions needed to evaluate the exact mechanism of action and to determine the optimal dietary inclusion level in order to optimize growth performance, nutrient digestibility and maintain healthy birds.

Table (1): Effects of prebiotics on productive performance

Source of product	Crud protein	Crude Fibre	Ether Extract	Dry Matter	Reference
inulin	NS	NS	NS	NS	Ratriyanto et al., 2009
inulin	NS	-	-	-	Biggs et al., 2007
Fructo-oligosaccharide	NS	NS	NS	NS	Janssens et al., 2004
chito-oligosaccharide	Sig*	Sig*	Sig*	Sig*	Wang et al., 2005
chito-oligosaccharide	Sig*	Sig*	Sig*	Sig*	Li et al., 2007

Table (2): Effects of prebiotics on nutrients digestibility

Source of product	Feed intake	BW gain	FCR	Mortality	Reference
MOS	sig *	sig*	sig *	NS	Toghyani et al., 2011
MOS	sig *	NS	sig*	-	Konca et al., 2009
Techno Mos	NS	sig*	NS	-	Murshed et al, 2015
MOS	sig*	sig*	sig*	NS	Sohail et al., 2012
MOS	sig*	sig*	sig*	-	Wang and Zhou, 2011
MOS	sig*	sig*	sig*	NS	Abdel-Raheem et al., 2011

Table (3): Effects of prebiotics on carcass criteria

Source of product	Live body weight	Carcass	liver	heart	gizzard	Intestine	bursa	cecum	Reference
MOS	-	NS	NS	NS	NS	NS	-	NS	Toghyani et al.,2011
MOS	-	NS	NS	NS	NS	NS	-	NS	Konca et al., 2009
MOS	-	NS	NS	NS	NS	NS	NS	NS	Midilli et al., 2008
MOS	NS	NS	NS	NS	NS	NS	NS	NS	Wang and Zhou,2011
MOS	NS	Sig*	NS	NS	NS	-	-	-	Abdel-Raheem et al., 2011
MOS	-	-	NS	-	NS	-	NS	-	Odefemi, 2016
MOS	-	NS	NS	NS	NS	NS	NS	NS	Mahmud et al., 2008

Table (4): Effect of prebiotic on microbial population

Source of product	E. coli	lactobacilli	Salmonella	Bifidobacteria	Clostridium perfringens	Reference
MOS and ,FOS	-	Sig*	-	-	-	Geier et al., 2008
MOS	Sig*	Sig*	-	Sig*	-	Baurhoo et al., 2007
FOS	Sig*	Sig*	-	Sig*	Sig*	Choi et al., 1993
MOS	NS	NS	-	--	Sig*	Sims et al., 2004
MOS	-	-	-	-	Sig*	Hofacre et al., 2005
MOS	-	Sig*	-	Sig*	-	Baurhoo et al., 2009
MOS	-	NS	Sig*	-	-	Spring et al., 2000
MOS	NS	NS	-	-	-	Abdel-Raheem et al., 2012
MOS	NS	-	-	-	Sig*	Ghosh et al.,2007
Inulin	NS	NS	NS	NS	NS	Ratriyanto et al., 2009

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الملخص العربى
تطبيقات البريبيوتك كاضافات غذائية في تغذية الدواجن –بحث مرجعي

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بسبب حظر استخدام الاتحاد الاوروبي للمضادات الحيوية كمنظمات للنمو في تغذية الدواجن فقد اجريت الكثير من البحوث لاستكشاف استخدام البدائل الفعالة الممكنة . تم ادخال منتجات البريبيوتك في علائق الدواجن لتحل محل منظمات النمو من اجل تحفيز وتعزيز الاستخدام الفعال للعناصر الغذائية و التي قد تؤدي لاحقا الى زيادة في معدلات الانتاج وتحسين الكفاءة الغذائية وتحفيز نمو ونشاط الكائنات الحية الدقيقة المفيدة . علاوة على ذلك قد يؤدي استخدام البريبيوتك الى تحسين عملية الهضم وتحفيز الجهاز المناعي في الدواجن . وبالتالي فقد اجريت العديد من الابحاث للتاكد من خصائصها المفيدة على الاداء الانتاجي الذي تمت دراسته بشكل رئيسي من خلال قياس استهلاك العلف وزيادة وزن الجسم وكفاءة التحويل الغذائي. واظهرت معظم التجارب اثار ايجابية طفيفة نتيجة استخدام البريبيوتك. وبما ان هناك احتمالات غير محدودة فيما يتعلق بمستويات وأنواع البريبيوتك فلا يزال هناك المزيد من البحوث اللازمة. لذلك فمن الضروري تحديد أنواع البريبيوتك المستخدمة في التجارب . وبصفة عامة يمكن القول بانه يمكن اعتبار البريبيوتك بديلا لمنظمات النمو في تغذية الدواجن . مع ذلك لا يزال هناك مزيد من البحوث تحت ظروف اكثر قياسية لازمة لتقييم المستويات المناسبة والالية الدقيقة لعملها.