Original Research

Effects of Mannan Oligosaccharide (MOS) and Xylo Oligosaccharide (XOS) Supplementation on the Growth Performance of Broilers

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Abstract

Antibiotics have been widely used in the field of poultry production as growth promoters for the last five decades. However, this practice has resulted in the development of antibiotic resistance in birds and human. Prebiotics can be used as an alternative to antibiotics to enhance the growth rate and upregulate the immune response of the host. In the present study, 108 numbers of day old broiler chicks were randomly divided in to 9 groups of 12 birds with 6 replicates in each group. The group T1 was kept as control. Birds in the other treatment groups were fed with different dietary concentrations of prebiotics - either mannan oligosaccharide (MOS) or xylo oligosaccharide (XOS) (T2– 0.2% MOS, T3 – 0.5% MOS, T4 – 0.75% MOS, T5 – 1% MOS, T6 - 0.2% XOS, T7 – 0.5% XOS, T8 – 0.75% XOS and T9 – 1% XOS) for a period of 42 days. The body weight was recorded at weekly intervals up to 42 days of age. Birds fed with 0.75% MOS (T4), 1% MOS (T5), 0.5% XOS (T7), 0.75% XOS (T8) and 1% XOS (T9) in their diet recorded significantly (P<0.05) higher body weight and feed conversion efficiency, when compared to the control and other treatment groups. There is no significant difference among the treatment groups T1 (control), T2 (0.2% MOS), T3 (0.5% MOS) and T6 (0.2% XOS) in the parameters studied. This study revealed that an optimum concentration of 0.75% of MOS and 0.5% of XOS can safely be included in the diet of broilers with beneficial effects on growth performance and immunomodulation.

Key words: Broilers, Mannan Oligosaccharide, Prebiotics, Xylo Oligosaccharide

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Introduction

Globally, India has emerged as one of the fastest growing and fourth largest poultry producer over the last decade. The growth rate of broiler industry is 8-10% per annum (Bajagai *et al*., 2016). The chicken meat is the cheapest source of animal protein available to the all the classes of people in the society. The primary aim of the poultry industry is to deliver the safe meat to the consumers without any antibiotic residues. From nutritional point of view, the use of antibiotics as feed additives was thought to be one of the major contributors for enhancement of productivity as well as control of diseases in the poultry industry (Samanta *et al*., 2013). However, continuous use of the antibiotics as feed additives has resulted in the development and transfer of antibiotic resistance gene from birds to human (Mathur and Singh, 2005). Hence, the European Union had banned the use of all antibiotic growth promoters in poultry feed since January, 2006 and several countries including India are on the way to restrict or replace feed usage of antibiotics in the poultry industry (Khare *et al*., 2018). Therefore, finding out an alternative to antibiotics which can act as a growth promoter is the need of the hour.

An effective alternative should mimic the beneficial effects of antibiotics on growth performance without the development of antibiotic resistance (Sarangi *et al*., 2018). Prebiotics can be used as an alternative to antibiotic growth promoters because of their beneficial effects on the growth performance and feed conversion efficiency (Al-Khalaifah, 2018). The use of prebiotics as a feed additive is well recognized for their importance in well-balanced gut microbial ecosystem in birds, because it ensures health and higher production performances. Following ban on the usage of antibiotics as growth promoters, prebiotics are the preferred choice of feed additives as they have the capability to selectively promote the growth and multiplication of beneficial gut microflora coupled with the inhibition of pathogenic microflora (Gaggia *et al*., 2010). Prebiotics are the substrates, selectively utilized by host microorganisms conferring a health benefit. The criterion of selective utilization distinguishes prebiotics from other feed additives. An advantage of prebiotics over probiotics is that they stimulate commensal bacteria that already exist in the gut and therefore well adapted to that environment (Gibson *et al*., 2004). Prebiotics are the potential candidates to be used as tools for early life programming in poultry (Rubio, 2018).

There are only few literatures available on the effectiveness of xylo oligosaccharide, a xylose based prebiotic on the growth performance of poultry. The xylo oligosaccharides (XOS) are the short chain carbohydrate molecules made up of xylose monomers linked by β-1, 4- linkages. Among the list of prebiotics used in poultry diet, xylo oligosaccharide is the only one that could be produced from the abundantly available, renewable and low cost agricultural byproducts unsuitable for human consumption such as corn cobs, corn husks, sugarcane bagasse, ragi straw and wheat straw (Samanta *et al*., 2017). Mannan oligosaccharides are short chain low molecular weight carbohydrate fragments of the yeast cell wall, particularly *Saccharomyces cerevisae* (Singh *et al.*, 2017). Mannan oligosaccharide supplementation

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has been reported to have a positive effect on the growth performance of poultry (Saeed, 2017 and Shanmugasundaram *et al*., 2012). Prebiotics such as β-glucan (Cox *et al*., 2010) and mannan oligosaccharides (Yitbarek *et al*., 2012) are promoted as alternatives to antibiotics or other chemotherapeutic agents in the poultry industry. Several health promoting effects of XOS and MOS including improvement of gut microbiota, calcium absorption and lipid metabolism had been reported (Das *et al*., 2012 and Samanta *et al*., 2017). In view of the above perspectives, the present research was aimed to assess the effects of MOS and XOS on body weight and feed conversion efficiency of broiler chicken.

Materials and Methods

This experiment was approved by the Institutional Animal Ethical Committee of Tamil Nadu Veterinary and Animal Sciences University (Approval Lr. No. 2140/SA/DFBS/IAEC/2017 dt, 30.10.2017). All procedures related to the birds and their care conformed to the internationally accepted principles in the Committee for the Purpose of Controlled Supervision on Experiments on Animals (CPCSEA) guidelines for laboratory animal facility.

Experimental Design

A total of 108 numbers of day old broiler chicks of Cobb 400 breed were obtained from a commercial hatchery (KPK Breeders and Feeds, Hosur). The birds were randomly divided in to 9 groups, each group comprising of 12 birds with 6 replicates in each group and assigned to 1 of 9 dietary treatments.

Table 1: Percent ingredient composition and nutrient profile of the experimental broiler diets

Ingredients (kg/100 kg)	Pre starter Diet	Starter Diet	Finisher Diet
Maize	55.4	58	62.8
Soya DOC	38.3	35.8	29.5
Calcite	1.21	1.35	1.5
DCP	1.8	1.75	1.47
Methionine	0.23	0.15	0.08
Lysine	0.09	0	0
Soda Bicarb	0.3	0.3	0.3
Salt	0.25	0.25	0.25
Palm oil	2	2	3.7
Additives	0.4	0.4	0.4
Total	100	100	100
Nutrient Profile			
Metabolizable Energy (Kcal/kg)	3017	3147	3185
Crude protein (%)	23.06	22.06	19.6
Calcium (%)	0.98	1	0.98
Total Phosphorus (%)	0.72	0.7	0.63
Available Phosphorus (%)	0.48	0.47	0.4
Lysine (%)	1.33	1.19	1.03
Methionine (%)	0.59	0.5	0.4
Methionine + Cystiene (%)	0.97	0.87	0.73

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The group T1 was kept as control. Birds in the other treatment groups were fed with different dietary concentrations of prebiotics either mannan oligosaccharide (MOS) or xylo oligosaccharide (XOS) (T2 – 0.2% MOS, T3 – 0.5% MOS, T4 – 0.75% MOS, T5 – 1% MOS, T6 - 0.2% XOS, T7 – 0.5% XOS, T8 – 0.75% XOS and T9 – 1% XOS) for a period of 42 days with *ad libitum* water and standard broiler ration prepared according to BIS, 2007 (Table 1). The body weight was recorded at weekly intervals up to 42 days of age and standard managemental practices were followed. The above formulations are meant for the control group (T1). Experimental diets for the treatment groups T2, T3, T4 and T5 were prepared by adding MOS @ 0.20%, 0.50%, 0.75% and 1.0 % levels respectively in the T1 formulation, replacing equal quantity of maize. Similarly, experimental diets for the treatment groups T6, T7, T8 and T9 were prepared by adding XOS @ 0.20%, 0.50%, 0.75% and 1.0 % levels respectively in the T1 formulation, replacing equal quantity of maize.

Results and Discussion

The feeding trial conducted in broiler chicken for a period of 42 days to assess the efficacy of MOS and XOS as feed additives in the poultry diet revealed enhanced growth rate and feed conversion efficiency.

Correlation between Body Weight and MOS Supplementation

The body weight of the broilers fed with different concentrations of MOS is presented in the Table 2. The initial body weight of chicks did not differ ($P>0.05$) between the control and treatment groups. At 28, 35 and 42 days of age, there is no significant difference between the control (T1) and T2 (0.20% MOS) group. At 28 days, the groups T3 (0.5% MOS) and T5 (1% MOS) revealed significant difference ($P<0.05$) in body weight when compared to the control (T1) group. However, the group T4 (0.75%) recorded significantly ($P<0.05$) higher body weight when compared to other treatment and control groups. At 35 days of age, group T4 (0.75% MOS) exhibited significantly higher ($P<0.05$) body weight than other treatment and control groups. At 42 days of age, the groups T4 (0.75% MOS) and T5 (1% MOS) recorded significantly ($P<0.05$) higher body weight compared to other groups.

The results of the present study are in accordance with Abdel-Hafeez *et al*. (2017) who reported 6% higher body weight gain than the control group when the diets of broilers were supplemented with different concentrations of MOS (2, 1 and 0.5 kg of MOS per ton of feed) in the starter, grower and finisher phase respectively. Recently, Abdel-Wareth *et al*. (2018) reported that supplementation of 1g MOS per kg diet of broilers for a period of 42 days significantly ($P<0.01$) improved the body weight gain. The weight gain of MOS supplemented group and control group were recorded as 2448 g and 2368 g, respectively.

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Table 2: Effect of supplementation of different concentrations of prebiotics on the cumulative body weight (kg) of broiler chicken

Treatments		Hatch weight	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
T1	Control	0.055 ± 0.002	0.151^{a} ± 0.002	0.400^{ab}± 0.003	0.834^{b}± 0.003	1.350^{ab} ± 0.003	1.694^{b} ± 0.018	1.712^{b} ± 0.009
Cumulative body weight (kg) of broiler chicken fed with different concentrations of MOS								
T2	0.20% MOS	0.052 ± 0.001	0.156^{a}± 0.002	0.418^{ab}± 0.003	0.836^{b} ± 0.003	1.369^{ab} ± 0.001	1.698^{b} ± 0.006	1.855^{b}±0.009
T3	0.50% MOS	0.051 ± 0.002	0.170^{b} ± 0.002	0.435^{b}± 0.002	0.896^{a} ± 0.004	1.413^{b} ± 0.006	1.811^{ab} ± 0.005	2.013^{c}±0.005
T4	0.75% MOS	0.052 ± 0.002	0.175^{ab} ± 0.003	0.454^{a}± 0.003	0.939^{ab} ± 0.004	1.513^{a} ± 0.003	1.913^{a} ± 0.005	2.221^{a}±0.012
T5	1.00% MOS	0.051 ± 0.005	0.176^{ab} ± 0.003	0.453^{b}± 0.002	0.927^{ab} ± 0.004	1.414^{a}± 0.005	1.810^{ab}± 0.020	2.008^{ab}±0.007
Cumulative body weight (kg) of broiler chicken fed with different concentrations of XOS								
T6	0.20% XOS	0.053 ± 0.002	0.158^{a} ± 0.002	0.423^{ab} ± 0.001	0.839^{b} ± 0.002	1.412^{b} ± 0.006	1.689^{b} ± 0.004	1.795^{b}±0.012
T7	0.50% XOS	0.051 ± 0.002	0.169^{b}± 0.002	0.445^{a}± 0.002	0.902^{a} ± 0.003	1.515^{a} ± 0.007	1.908^{a} ± 0.010	2.227^{a}±0.013
T8	0.75% XOS	0.053 ± 0.002	0.171^{ab} ± 0.002	0.449^{a} ± 0.003	0.929^{ab}± 0.003	1.513^{a} ± 0.007	1.903^{a}±0.004	2.210^{a}±0.014
T9	1.00% XOS	0.051 ± 0.008	0.173^{ab}± 0.002	0.450^{b}± 0.003	0.931^{ab} ± 0.005	1.519^{a} ± 0.007	1.801^{ab}± 0.008	2.007^{ab}±0.015
	F value	0.340^{NS}	2.954*	6.384**	4.807**	2.757*	6.606**	3.360*

*NS – non significant (P>0.05), Mean values bearing different superscripts within a column differ ** significantly (P<0.01), *significantly (P<0.05)*

Khose *et al*. (2018) also reported that supplementation of a nutritional formula containing amino acids, vitamin E and MOS at the level of 750 gm/ton of feed significantly improved the body weight and feed conversion efficiency in broilers. On the contrary, Park *et al*. (2017) could not find significant difference in the body weight gain in broilers fed with 0.2% MOS in their diet for a period of 42 days.

Correlation between Body Weight and XOS Supplementation

The body weight of the broilers fed with different concentrations of XOS prebiotics is presented in the Table 2. The initial body weight of chicks did not differ (P>0.05) between the control and treatment groups. At 28 days of age, there is no significant difference in body weight among the T7, T8 and T9 groups. However, these groups exhibited significance difference (P<0.05) in body weight when compared to the control group. At 35 days of age there is no significant difference between groups T7 and T8 but when compared to the control, both the groups revealed significance difference (P<0.05) in 0.5% and 0.75% XOS respectively. At 42 days of age, the group T7 and T8 revealed significant difference (P<0.05) compared to the control group at 0.5% and 0.75% XOS respectively. The results of present study are in accordance with Zhenping *et al*. (2013) and De Maesschalck *et al*. (2015) who reported higher body weight gain in broilers supplemented with 1% and 0.5% XOS. On the contrary, Samanta *et al*. (2017) could not find significant difference in body weight when the diet of broilers were supplemented with 0.5% XOS for a period of 42 days.

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Correlation between Feed Conversion Ratio (FCR) and MOS/XOS Supplementation

The feed conversion ratio of the broilers fed with different concentrations of MOS/XOS is presented in the Table 3. At 42 days of age, group T4 (0.75% MOS) recorded significantly (P<0.01) higher feed conversion efficiency and lower feed conversion ratio when compared to other treatment and control groups. Abdel-Hafeez *et al*. (2017) recorded higher feed conversion efficiency when the diets of broilers were supplemented with 2 kg of MOS per ton of feed than the control group. Abdel-Wareth *et al*. (2018) demonstrated higher feed conversion efficiency in broilers with supplementation of 1g MOS per kg feed than the control group. The FCR in MOS supplemented and control groups were 1.291 and 1.394 respectively.

Table 3: Effect of supplementation of different concentrations of prebiotics on the cumulative feed conversion ratio of broiler chicken

Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
T1 – Control	1.490 ± 0.005	1.60^{abc} ± 0.005	1.67^{a} ± 0.010	1.75^{a} ± 0.014	1.84^{ab} ± 0.026	2.13^{a} ± 0.030
Cumulative feed conversion ratio of broiler chicken fed with different concentrations of MOS						
T2 – MOS – 0.2%	1.47 ± 0.005	1.55^{d} ± 0.006	1.63^{cd} ± 0.014	1.74^{a} ± 0.008	1.82^{bc} ± 0.014	2.11^{a} ± 0.050
T3 – MOS – 0.5%	1.47 ± 0.012	1.60^{ab} ± 0.006	1.66^{ab} ± 0.011	1.76^{a} ± 0.006	1.86^{ab} ± 0.010	2.05^{ab} ± 0.071
T4 - MOS –0.75%	1.46 ± 0.014	1.56^{cd} ± 0.012	1.63^{cd} ± 0.014	1.70^{c} ± 0.005	1.75^{d} ± 0.008	1.93^{b} ± 0.035
T5 - MOS – 1.0%	1.48 ± 0.012	1.61^{a} ± 0.006	1.68^{a} ± 0.006	1.71^{c} ± 0.017	1.78^{cd} ± 0.015	2.11^{a} ± 0.051
Cumulative feed conversion ratio of broiler chicken fed with different concentrations of XOS						
T6 – XOS – 0.2%	1.51 ± 0.015	1.61^{a} ± 0.010	1.65^{bc} ± 0.005	1.73^{a} ± 0.018	1.89^{a} ± 0.003	2.03^{ab} ± 0.030
T7 – XOS – 0.5%	1.48 ± 0.016	1.55^{d} ± 0.008	1.62^{d} ± 0.008	1.69^{c} ± 0.021	1.83^{bc} ± 0.033	1.90^{b} ± 0.021
T8 – XOS –0.75%	1.48 ± 0.014	1.58^{bcd} ± 0.013	1.66^{ab} ± 0.003	1.68^{c} ± 0.014	1.87^{ab} ± 0.013	1.93^{b} ± 0.030
T9 – XOS – 1.0%	1.49 ± 0.006	1.61^{a} ± 0.010	1.68^{ab} ± 0.000	1.77^{a} ± 0.014	1.86^{ab} ± 0.009	2.03^{ab} ± 0.020
F value	0.940^{NS}	6.384**	4.807**	2.757*	6.606**	3.360*

*NS – non significant (P>0.05), Mean values bearing different superscripts within a column differ ** significantly (P<0.01), *significantly (P<0.05)*

Among the XOS treated groups, at 42 days of age, group T7 (0.5% XOS) and T8 (0.75% XOS) recorded significantly (P<0.01) higher feed conversion efficiency when compared to other treatment and control groups. The results of the present study are in agreement with Zhenping *et al*. (2013) who reported 4.18% higher feed conversion efficiency in broilers with 1% XOS supplementation in their diet. De Maesschalck *et al*. (2015) also reported that feed conversion efficiency was significantly (P<0.05) higher for broilers fed with the diet supplemented with 0.5% XOS than the control group. However, Samanta *et al*. (2017) and Park *et al*. (2017) could not observe significant improvement in feed conversion efficiency with supplementation of 0.5% XOS and 0.2% MOS respectively in the diet of broilers for a period of 42 days.

Conclusion

The present study indicates that 0.75% of mannan oligosaccharide (MOS) and 0.5% of xylo oligosaccharide (XOS) can safely be included in the diet of broilers as better alternatives to antibiotic growth promoters

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since supplementation of MOS and XOS resulted in significant improvement in the growth and feed conversion efficiency.

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References

1. Abdel-Hafeez, H. M., Saleh, E. S., Tawfeek, S. S., Youssef, I. M. and Abdel-Daim, A. S. (2017). Effects of probiotic, prebiotic, and synbiotic with and without feed restriction on performance, hematological indices and carcass characteristics of broiler chickens. *Asian-Australasian Journal of Animal Sciences*, *30*(5), 672.
2. Abdel-Wareth, A. A. A., Hassan, H. A., Abdel rahman, W., Ismail, Z. S. H., Ali, R. A. M., Ahmed, E. A. and Lohakare, J. (2018). Growth performance, carcass criteria and serum biochemical parameters of broiler chickens supplemented with either synbiotic or prebiotic under hot climatic conditions. *British Poultry Science*, 3, 1-6.
3. Al-Khalaifah, H. S. (2018). Benefits of probiotics and/or prebiotics for antibiotic-reduced poultry. *Poultry Science*, *97*(11), 3807-3815.
4. Bajagai, Y. S., Klieve, A. V., Dart, P. J. and Bryden, W. L. (2016). *Probiotics in animal nutrition: production, impact and regulation*. FAO. *Animal Production and Health*. Paper No. 179. Rome.
5. BIS, 2007. Bureau of Indian Standards of poultry feed. Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi, India.
6. Cox, C. M. and Dalloul, R. A. (2010). Beta-glucans as immunomodulators in poultry: use and potential applications. *Avian Biology Research*, *3*(4), 171-178.
7. Das, D., Mukhopadhyayay, S. K., Ganguly, S., Kar, I., Dhanalakshmi, S., Singh, Y. D. and Pal, S. (2012). Mannan oligosaccharide and organic acid salts as dietary supplements for Japanese quail (Coturnix Coturnix Japonica). *International Journal of Livestock Research*, *2*(3), 211-214.
8. De Maesschalck, C., Eeckhaut, V., Maertens, L., De Lange, L., Marchal, L., Nezer, C. and Haesebrouck, F. (2015). Effects of xylo-oligosaccharides on broiler chicken performance and microbiota. *Applied and Environmental Microbiology*, *81*(17), 5880-5888.
9. Gaggìa, F., Mattarelli, P. and Biavati, B. (2010). Probiotics and prebiotics in animal feeding for safe food production. *International Journal of Food Microbiology*, *141*, S15-S28.
10. Gibson, G. R., Probert, H. M., Van Loo, J., Rastall, R. A., Roberfroid, M. B. (2004). Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. *Nutrition Research Reviews*, *17*(2), 259-275.
11. Khare, A., G. Thorat, A. Bhimte and V. Yadav, (2018). Mechanism of action of prebiotic and probiotic. *Journal of Entomology and Zoological Studies*, 6 (4), 51-53.
12. Khose, K.K., Dhumal, M.V., Nikam M.G. and Rindhe, S.N.(2018). Effect of Amino Acid, Vitamin E, Selenium, MOS and Biotin Nutritional Formula Supplementation Through Feed at Different Dose Levels on Performance of Broiler Chicken *International Journal of Livestock Research*,8(3),70-79.
13. Mathur, S. and Singh, R. (2005). Antibiotic resistance in food lactic acid bacteria—a review. *International journal of food microbiology*, *105*(3), 281-295.

 DOI 10.5455/ijlr.20190121070954

14. Park, S. H., Lee, S. I., Kim, S. A., Christensen, K. and Ricke, S. C. (2017). Comparison of antibiotic supplementation versus a yeast-based prebiotic on the cecal microbiome of commercial broilers. *PloS one*, *12*(8), e0182805.
15. Rubio, L. A. (2018). Possibilities of early life programming in broiler chickens via intestinal microbiota modulation. *Poultry Science*. 10, 1-12.
16. Saeed, S. (2017). Use of mannan oligosaccharide as a feed additive in poultry nutrition. *Journal of World Poultry Res*earch, 7(3), 94-103.
17. Samanta, A. K., Jayapal, N., Senani, S., Kolte, A. P. and Sridhar, M. (2013). Prebiotic inulin: Useful dietary adjuncts to manipulate the livestock gut microflora. *Brazilian Journal of Microbiology*, *44*(1), 1-14.
18. Samanta, A. K., Kolte, A. P., Elangovan, A. V., Dhali, A., Senani, S., Sridhar, M. and Jayapal, N. (2017). Effects of corn husks derived xylo oligosaccharides on performance of broiler chicken. *Indian Journal of Animal Sciences*, *87*(5), 640-643.
19. Sarangi, N. R., Babu, L. K., Kumar, A., Mishra, J. and Behera, M. K. (2017). Effects of prebiotic, probiotic and synbiotic on serum biochemical and immunological status of broiler chickens in hot climatic conditions of Odisha. *International Journal of Livestock Research*, 8(1), 112-120.
20. Shanmugasundaram, R., Sifri, M. and Selvaraj, R. K. (2013). Effect of yeast cell product (CitriStim) supplementation on broiler performance and intestinal immune cell parameters during an experimental coccidial infection. *Poultry Science*, *92*(2), 358-363.
21. Singh, A. K., Kerketta, S., Yogi, R. K., Kumar, A. and Ojha, L. Prebiotics-The New Feed Supplement for Dairy Calf. *International Journal of Livestock Research*, 7(8), 1-17.
22. Yitbarek, A., Echeverry, H., Brady, J., Hernandez-Doria, J., Camelo-Jaimes, G., Sharif, S., and Rodriguez-Lecompte, J. C. (2012). Innate immune response to yeast-derived carbohydrates in broiler chickens fed organic diets and challenged with *Clostridium perfringens*. *Poultry Science*, *91*(5), 1105-1112.
23. Zhenping, S., Wenting, L., Ruikui, Y., Jia, L., Honghong, L., Wei, S. and Yuling, Q. (2013). Effect of a straw-derived xylo oligosaccharide on broiler growth performance, endocrine metabolism, and immune response. *Canadian Journal of Veterinary Research*, *77*(2), 105-109.

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