

COMPARATIVE EFFECTS OF DIFFERENT DIETARY CONCENTRATIONS OF - GALACTO-OLIGOSACCHARIDES ON GROWTH PERFORMANCE, FEED CONVERSION EFFICIENCY AND ORGANS DEVELOPMENT IN BROILERS

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ABSTRACT

The study was carried out to compare the effects of three different dietary concentrations of -galacto-oligosaccharides (-GOS) on broilers growth performance, feed intake, feed conversion efficiency and organs development. For this study, two hundred, one day old, Hubbard broiler chicks were procured from the commercial hatchery. All the birds were randomly divided into four groups (n = 50), each having five replicas (n = 10). One of the four groups was kept as control (-GOS-0) and was given corn based basal diet, whereas, birds in other groups were given same basal diets supplemented with -GOS at 0.1% (-GOS-1), 0.2% (-GOS-2) or 0.5% (-GOS-5) for a period of five weeks. Body weights, feed intake and feed conversion efficiency (FCE) were determined on weekly basis. On day 35, ten birds from each group were slaughtered to collect viscera for organs development. Data were analyzed by one way analysis of variance technique and incase of significant (P < 0.05) results, Tukey's post hoc test was applied. Results demonstrated that growth performance and feed conversion efficiency of -GOS supplemented birds were improved (P < 0.05) in a dose dependent manner, being the highest body weight (P < 0.05) and improved FCE (P < 0.05) were observed in -GOS-5 group. Relative weights of liver and pancreas were higher (P < 0.05) in -GOS-1 group. In conclusion, birds supplemented with 0.5% -GOS outperformed other supplemented and control groups in growth performance and feed conversion efficiency.

Keywords: -galacto-oligosaccharides, growth performance, feed conversion efficiency, organs development, broilers.

INTRODUCTION

Digestion, metabolism and bioavailability of nutrients are primarily regulated by the gastrointestinal tract (GIT) and any disturbance or malfunction of GIT results in poor digestibility and bioavailability of nutrients as well as microbial dysbiosis in intestinal tract. Therefore, it can lead to reduced growth and feed intake, impaired feed efficiency and high death rate in animals (Dibner and Richards, 2005). The microbes inhabiting the GIT play pivotal role in digestion, metabolism, growth and overall health of the animals (Dibner and Buttin, 2002; Torok *et al.*, 2011). Despite their beneficial effects, these microbes also compete for energy and nutrients utilization with the host-animal. It is, therefore, desirable to shift energy and nutrients more towards the host animal than GIT inhabiting microbiota that can ultimately improve the growth and production performance of animals. Since many decades it was successfully managed by inclusion of sub-therapeutic concentrations of antibiotics in livestock and poultry feed (Huyghebaert *et al.*, 2011). However, in 2006, European commission banned the inclusion of sub-therapeutic doses of antibiotics in animal and poultry feed. It results in

emergence of sub-clinical infections, poor growth rate and high mortality among the flocks. Therefore, many feed additives like prebiotics, probiotics, phytobiotics, organic acids and essential oils are proposed to replace the antibiotics in animal feed and to improve the digestibility and bioavailability of nutrients that can ultimately enhance the animal performance (Wenk, 2002; Huyghebaert *et al.*, 2011).

Prebiotics is a group of substances which are oligosaccharides containing hexose monosaccharides like mannose, fructose, glucose and galactose (Durst, 1996) with different degree of polymerization (d.p.) ranging between two to twenty monosaccharides. Prebiotic galacto-oligosaccharides (GOS), d.p. between two to ten, is produced by enzymatic transgalactosylation of lactose by -galactosidase (Prensil *et al.*, 1987) from different bacteria, yeast or fungi with variable glycosidic linkages (Ekhart and Timmermans, 1996; Otieno, 2010) based upon enzyme source. In addition to the production of GOS, lactose fermentation also yields other non-prebiotics compounds like glucose and galactose. Prebiotic GOS is studied in pigs (Smiricky-Tjardes *et al.*, 2003) and poultry (Biggs *et al.*, 2007; Jung *et al.*, 2008).

In an experiment, designed by Jung *et al.* (2008), prebiotics GOS and probiotics Bifidobacteria were supplemented in single or combination to the broiler chickens to evaluate the effects on performance and microbial populations. No significant differences in body weight, feed intake and feed conversion efficiency (FCE) were found among different treatment groups (Jung *et al.*, 2008). Similar observations were stated in the previous studies on inclusion of GOS to the poultry and pigs (Mountzouris *et al.*, 2006; Biggs *et al.*, 2007) with no effects on performance parameters. The health related consequences of short-chain fructo-oligosaccharides and GOS supplementation were also investigated in healthy adult cats by feeding them with different dietary plans and it was found that food intake was not different among groups (Kanakupt *et al.*, 2011). Supplementation of GOS to the human infants revealed that weight gain and body height remained unchanged among groups (Ben *et al.*, 2008).

The aim of the present study is to investigate the effects of different dietary concentrations of second generation β -galacto-oligosaccharides (Bimuno™, Clasado Limited, United Kingdom), produced by transgalactosylation of lactose by β -galactosidase of *Bifidobacterium bifidum* NCIMB 41171, on growth performance, feed conversion efficiency, and organs development in broilers.

MATERIALS AND METHODS

Experimental Design: The experiment included 200, one day old, Hubbard broiler chicks that were procured from local hatchery and kept in control house at Phoolnagar, Pattoki. All the animals were divided into four units (n = 50) having five replicates (n = 10) in each unit. During the brooding phase, temperature and relative humidity were maintained at $35 \pm 1^\circ\text{C}$ and $65 \pm 5\%$, respectively. Thereafter, temperature was reduced by 3°C weekly until it reached 26°C which was maintained throughout the experiment. The birds were fed a corn-based basal diet (Table 1), formulated free of antimicrobials and coccidiostats to meet or exceed the recommendations of the "National Research Council" (NRC, 1994), or same basal diet supplemented with different concentrations of β -galacto-oligosaccharides (β -GOS). The β -GOS power mixture contains "monosaccharides 15-17%, lactose 22%, disaccharides 18-25%, trisaccharides 20-25%, tetrasaccharides 8-12% and pentasaccharides 7-10%".

Animals in the control (β -GOS-0) group were given basal diet, whereas animals in supplemented groups were given basal diets added with 0.1% β -GOS (β -GOS-1), 0.2% β -GOS (β -GOS-2) and 0.5% β -GOS (β -GOS-5), *ad libitum*, for entire experimental period.

Growth Performance and Feed Conversion Efficiency: Body weights and feed intake of birds were measured on weekly basis and mortality was recorded on daily basis, and the data were used for calculation of feed conversion efficiency.

Sampling Protocols: At the end of experiment, 10 birds from each group (2 birds / replica) were slaughtered by exsanguination. The birds were weighed and abdominal cavity of each bird was exposed to collect viscera. Viscera were weighed and lengths of small intestines and caeca were measured. Absolute weights of viscera were used to calculate relative weights.

Statistical Analysis: Data were analyzed by using Statistical Package for Social Science (SPSS for Windows Version 13.0, SPSS Inc., Chicago, IL, USA). Normal distribution of data was confirmed by Shapiro-Wilk test. Data were analyzed by one-way analysis of variance technique. In case of significant results, data were further analyzed by Tukey's post-hoc test. Significance level was set at $P < 0.05$ and data were presented as means \pm SE.

RESULTS

Growth Performance: Body weights of birds supplemented with 0.2% and 0.5% of β -GOS were higher ($P < 0.05$) compared with the control group during the first two weeks, whereas, no differences in the body weights were observed between 0.1% β -GOS supplemented and control groups. Moreover, body weights of 0.5% β -GOS supplemented birds were higher compared with the 0.1% β -GOS birds during first two weeks of experimental period. During the third week, body weights of all the β -GOS supplemented birds were higher ($P < 0.05$) compared with the control birds. Body weights of 0.5% β -GOS supplemented birds were higher ($P < 0.05$) during the fourth and fifth weeks of experiment compared with other experimental groups (Table 2).

Feed Conversion Efficiency: Feed intake in all the experimental groups remained same and no significant differences were observed (Table 3). Feed conversion efficiency remained same among all experimental groups during the period of first two weeks. However, during the third week, feed conversion efficiency was better ($P < 0.05$) in all the β -GOS supplemented groups compared with the control group. During the fourth and fifth weeks, feed conversion efficiency was better ($P < 0.05$) in 0.5% β -GOS supplemented birds compared with other experimental birds (Table 4).

Organs Development: Relative weights of liver were higher ($P < 0.05$) in the 0.1% β -GOS supplemented birds compared with the control and 0.5% β -GOS

supplemented birds, whereas, relative weights of pancreas were higher ($P < 0.05$) in the 0.1% -GOS supplemented birds compared with all the treatment groups. However, relative weights of heart, gizzard,

spleen, small intestine and caecum, and relative lengths of small intestine and caecum were remained unchanged among all the experimental groups (Table 5).

Table 1. Feed ingredients, proximate composition and calculated AME of the starter (1-21 days of age) and grower diets (22-35 days of age) for broilers.

	Starter	Grower
Feed Ingredients (%)		
Corn	40.15	57.57
Rice broken	15.0	----
rice polish	----	4.00
Wheat bran	1.34	----
Soya meal	11.54	9.60
Sunflower meal	12.00	13.00
Canola meal	9.00	5.00
Rapeseed meal	5.00	7.60
Guar meal	1.00	----
Molasses	2.00	----
Dicalcium phosphate	1.73	1.96
Premix*	1.00	1.00
Sodium chloride	0.21	0.21
Sodium bicarbonate	0.03	0.065
Proximate Composition (%)		
Crude protein	19.6	18.5
Crude fat	2.16	2.35
Crude fiber	1.26	1.80
Total ash	5.77	5.40
Calculated AME (Kcal/kg)	2,750	2,850

*Vitamin mineral premix (each kg contained): Ca, 195 g; K, 70 g; Na, 18 g; Mg, 6 g; Zn, 4,000 mg; Fe, 8,000 mg; Cu, 800 mg; Mn, 6,200 mg; Se, 15 mg; Co, 35 mg; I, 40 mg; vitamin A, 200,000 IU; vitamin D3, 80,000 IU; vitamin E, 1072 IU; vitamin K3, 34 mg; ascorbic acid, 1,300 mg; thiamine, 180 mg; riboflavin, 350 mg; niacin, 3,500 mg; vitamin B6, 320 mg; folic acid, 50 mg; vitamin B12, 800 µg; biotin, 13,000 µg.

Table 2. Comparative effects of different dietary concentrations of -galacto-oligosaccharides on body weights (g ± SE) of broilers.

Period	Treatments			
	-GOS-0	-GOS-1	-GOS-2	-GOS-5
1 st Week	153 ± 1.7 ^c	158 ± 3.0 ^{bc}	164 ± 1.3 ^{ab}	170 ± 1.1 ^a
2 nd Week	356 ± 2.4 ^c	371 ± 5.2 ^{bc}	384 ± 4.1 ^{ab}	390 ± 3.8 ^a
3 rd Week	725 ± 6.9 ^b	753 ± 2.7 ^a	756 ± 2.7 ^a	761 ± 1.1 ^a
4 th Week	1098 ± 19.0 ^b	1121 ± 9.6 ^b	1143 ± 9.2 ^b	1227 ± 19.3 ^a
5 th Week	1514 ± 51.1 ^b	1516 ± 18.0 ^b	1574 ± 27.0 ^b	1722 ± 18.4 ^a

Different superscripts^{a-c} in a column differed significantly ($P < 0.05$)

Table 3. Comparative effects of different dietary concentrations of -galacto-oligosaccharides on feed intake (g ± SE) of broilers.

Period	Treatments			
	-GOS-0	-GOS-1	-GOS-2	-GOS-5
1 st Week	135 ± 3.2	135 ± 4.4	133 ± 4.6	133 ± 5.2
2 nd Week	426 ± 9.3	424 ± 9.1	430 ± 6.9	428 ± 4.6
3 rd Week	913 ± 6.4	911 ± 4.9	908 ± 5.3	912 ± 6.0
4 th Week	1562 ± 17.6	1571 ± 11.8	1578 ± 6.8	1570 ± 9.1
5 th Week	2453 ± 17.6	2443 ± 21.3	2447 ± 16.2	2439 ± 15.9

Table 4. Comparative effects of different dietary concentrations of -galacto-oligosaccharides on feed conversion efficiency (ratio \pm SE) of broilers

Period	Treatments			
	-GOS-0	-GOS-1	-GOS-2	-GOS-5
1 st Week	0.88 \pm 0.03 ^a	0.85 \pm 0.03 ^a	0.81 \pm 0.03 ^a	0.78 \pm 0.03 ^a
2 nd Week	1.19 \pm 0.03 ^a	1.14 \pm 0.04 ^a	1.12 \pm 0.03 ^a	1.10 \pm 0.02 ^a
3 rd Week	1.26 \pm 0.02 ^a	1.21 \pm 0.01 ^b	1.20 \pm 0.01 ^b	1.20 \pm 0.01 ^b
4 th Week	1.43 \pm 0.04 ^a	1.40 \pm 0.02 ^a	1.38 \pm 0.01 ^a	1.28 \pm 0.02 ^b
5 th Week	1.63 \pm 0.05 ^a	1.61 \pm 0.03 ^a	1.55 \pm 0.03 ^a	1.42 \pm 0.01 ^b

Different superscripts^{a-b} in a column differed significantly ($P < 0.05$)

Table 5. Comparative effects of different dietary concentrations of -galacto-oligosaccharides on relative organs characteristics (ratio \pm SE) of broilers.

Organs	Treatments			
	-GOS-0	-GOS-1	-GOS-2	-GOS-5
Weights				
Heart	0.45 \pm 0.01 ^a	0.49 \pm 0.02 ^a	0.48 \pm 0.02 ^a	0.49 \pm 0.02 ^a
Gizzard	1.71 \pm 0.04 ^a	1.84 \pm 0.08 ^a	1.76 \pm 0.03 ^a	1.73 \pm 0.09 ^a
Liver	2.45 \pm 0.09 ^b	2.80 \pm 0.09 ^a	2.61 \pm 0.08 ^{ab}	2.35 \pm 0.08 ^b
Pancreas	0.22 \pm 0.01 ^b	0.28 \pm 0.02 ^a	0.23 \pm 0.01 ^b	0.23 \pm 0.01 ^b
Spleen	0.11 \pm 0.01 ^a	0.16 \pm 0.02 ^a	0.13 \pm 0.02 ^a	0.12 \pm 0.01 ^a
Small Intestine	2.15 \pm 0.10 ^a	2.32 \pm 0.10 ^a	2.15 \pm 0.06 ^a	2.31 \pm 0.09 ^a
Caecum (Filled)	0.52 \pm 0.04 ^a	0.49 \pm 0.04 ^a	0.52 \pm 0.04 ^a	0.45 \pm 0.04 ^a
Caecum (Empty)	0.28 \pm 0.01 ^a	0.30 \pm 0.02 ^a	0.32 \pm 0.01 ^a	0.28 \pm 0.01 ^a
Lengths				
Small Intestine	3.16 \pm 0.07 ^a	3.45 \pm 0.07 ^a	3.18 \pm 0.09 ^a	3.24 \pm 0.12 ^a
Caecum	0.64 \pm 0.02 ^a	0.64 \pm 0.04 ^a	0.64 \pm 0.02 ^a	0.64 \pm 0.02 ^a

Different superscripts^{a-b} in a column differed significantly ($P < 0.05$).

DISCUSSION

Prebiotics being "non-digestible feed ingredients", improve the host health by favorably increasing the selective populations of beneficial microbes that harbor the gastrointestinal tract of birds (Hume, 2011; Huyghebaert *et al.*, 2011). However, desirable effects of prebiotics vary that depend upon many crucial factors like nature of prebiotic, concentration, hygienic status of the feed and production unit as well as animal species (Ten Bruggencate *et al.*, 2003; Verdonk *et al.*, 2005; Biggs *et al.*, 2007; Yang *et al.*, 2009). The present study demonstrates the effects of different dietary concentrations of -galacto-oligosaccharides (-GOS) on growth performance, feed conversion efficiency and organs characteristics in broilers.

Results of present study demonstrate that growth performance and feed conversion efficiency are affected by the -GOS supplementation in a dose dependent manner. It is evident from results that the 0.5% -GOS supplementation significantly improved the growth performance and feed conversion efficiency of broilers during grower phase compared with the control and other

supplemented groups. The 0.5% -GOS supplementation, on an average, improves 11.4% body weights and 13% feed conversion efficiency during the fifth week of performance compared with the control group. Contrary to our findings, Jung *et al.* (2008) reported that dietary supplementations of 3% and 12% GOS in syrup form, with or without *Bifidobacterium lactis* supplementation, have no beneficial effects on growth performance and feed conversion efficiency in broilers. Similar findings on growth performance and feed conversion efficiency were also reported in trans-GOS supplemented poultry (Biggs *et al.*, 2007) and pigs (Mountzouris *et al.*, 2006). Improved growth performance and feed conversion efficiency, in our trial, can be attributed to improved nutrients digestibility and bioavailability, short chain fatty acids production, shift in caecal microbial ecology or immuno-modulation. Few trials have been conducted to elucidate the effects of GOS supplementation on nutrients digestibility in poultry and cat with no positive effects on nutrients digestibility (Biggs *et al.*, 2007; Kanakupt *et al.*, 2011). However, Biggs *et al.* (2007) reported that dietary supplementation of high levels of oligosaccharides (0.8%) including oligofructose, short chain fructo-oligosaccharides and trans-galacto-oligosaccharides in poultry diets depress the

metabolizable energy and amino acids digestibility, and, therefore, low levels of oligosaccharides supplementation (0.4%) were recommended. *In vivo* and *in vitro* studies demonstrated that GOS fermentation resulted in an increased short chain fatty acids production (Tzortzis *et al.*, 2005; Ben *et al.*, 2008; Kanakupt *et al.*, 2011; Cardelle-Cobas *et al.*, 2012) that may favorably improve the growth performance and feed conversion efficiency in supplemented subjects.

Results of organs characteristics, in this study, revealed that 0.1% -GOS supplementation increased the relative weights of liver and pancreas. The liver is of prime importance in supplying nutrients and energy metabolites to the body organs (Zuidhof *et al.*, 2006), therefore, an increase in liver weight can be related with improved growth performance. Likewise, increase in pancreas weight is also related with increased enzymatic activities and secretions (Nahas and Lefrancois, 2001) that can result in improved feed digestibility and ultimately improved growth performance. However, no differences in growth performance and feed conversion efficiency were observed in the 0.1% -GOS supplemented group compared with the control group. Therefore, no relation can be depicted between liver and pancreas weights with growth performance.

It can be concluded that 0.5% -GOS has a potential to improve growth performance and feed conversion efficiency in broilers. However, further studies are warranted to confirm the effects of -GOS supplementation on nutrients digestibility and short chain fatty acids production in poultry.

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