International Journal of Agricultural Technology 2018 Vol. 14(7): 1743-1754
Available online http://www.ijat-aatsea.com
ISSN: 2630-0613 (Print) 2630-0192 (Online)

The effect of supplementation of synbiotic in broiler diets on production performance, intestinal histomorphology and carcass quality

Raksasiri, B. V.[1*], Paengkoum, P.[2], Paengkoum, S.[3] and Poonsuk, K.[4]

[1]Faculty of Animal sciences and Agricultural Technology, Silpakorn University, Cha-am, Petchaburi, 76120 Thailand. [2]School of Animal Production Technology, Institute of Agricultural Technology, Suranaree University of Technology, Muang Nakhon Ratchasima, 30000 Thailand. [3]Program in Agriculture, Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Muang Nakhon Ratchasima, 30000 Thailand And [4]K.M.P. BIOTECH CO.,LTD., Muang Chonburi, Chonburi, 20000 Thailand.

Raksasiri, B. V., Paengkoum, P., Paengkoum, S. and Poonsuk, K. (2018). The effect of supplementation of synbiotic in broiler diets on production performance, intestinal histomorphology and carcass quality. International Journal of Agricultural Technology 14(7): 1743-1754.

Abstract The effect of synbiotic in broiler diets on productive performance, intestinal histomorphology and carcass quality was investigated. Jerusalem artichoke (*Helianthus tuberosus* L.) and BACTOSAC-P® were used as synbiotic sources, respectively. Four hundred Ross 308 chickens were assigned into a Complete Randomized Design (CRD) with 4 replicates (25 chickens per replicate). There were four dietary treatments: control diet (T1), synbiotic supplemented 0.025 % of DM (T2), 0.050 % of DM (T3) and 0.075 % of DM (T4) in broiler diets, respectively. A data was collected at 42 days old for productive performance, intestinal histomorphology, and carcass qualities. Jerusalem artichoke and BACTOSAC-P® were used at ratio 1:9 (w/w) at the sources of prebiotic and probiotic, respectively. The results showed that feed intake were significantly different ($p<0.05$), specifically with the supplementation of synbiotic at 0.05% of DM. Use of synbiotics at higher levels were affected on decrease feed conversion ratios ($P<0.05$) in all the groups are synbiotic supplementation. And dietary supplementation of 0.05% of DM synbiotic significantly ($P<0.05$) increased the villus height. Moreover, it was found that decrease ammonia concentration in the intestinal and found a decrease of visceral fat was with synbiotic 0.05% of DM ($P<0.05$) of chicken feed supplementation of synbiotic were not affected on crypt depth, lactic acid bacteria, carcass quality and meat quality. Based on this study, it was concluded that supplementation of synbiotics could improve FCR and reduce ammonia concentration in the intestinal tract.

Keywords: Broiler, Synbiotic, Intestinal histomorphology, Productive performance and Carcass quality

[*] **Corresponding Author:** Raksasiri, B.V., **Email:** bhutharit@gmail.com

Introduction

Prebiotics are characterized as non-edible starches and indigestible fermentable diet substances that advantageously influence the host by specific alteration of the intestinal microflora (Roberfroid, 2000; Propst *et al*., 2003; Gaggı`a *et al*., 2010). And fructans arranged are a standout amongst the most popular prebiotic supplements accessible and incorporate short-chain fructooligosaccharides (scFOS), oligofructose (OF) and inulin (Flickinger *et al*., 2003). Fructans are matured by gainful sorts of colonic microorganisms (Bifidobacterium and Lactobacillus) and have the potential to prevent the intrusion of pathogenic bacterial species for example *Escherichia coli*, *Clostridium* spp. and *Salmonella* spp. (Flickinger *et al*., 2003; Barry *et al*., 2009). The sue of fructans by beneficial microflora increases the creation of short-chain unsaturated fatty acids (SCFA), acetic acid derivatives, propionate and butyrate, which are bactericidal substances (Saavedra, 2005; De Vrese and Marteau, 2007) increase SCFA production reduces pH in the colon, which smothers the growth of potential pathogens (Swanson *et al*., 2002; Barry *et al*., 2009).

Inulin contains fructooligosaccharides (FOS) with chain lengths changing somewhere around 3 and 65 monomers (Apanavicius *et al*., 2007) and may be more complete in the colon because of the higher levels of opposite polymerization contrasted (Flickinger *et al*., 2003; Bosscher, 2009). It has been demonstrated that gradually maturing fructans can be endured more effectively than speedier aging fructans (Bosscher, 2009), which may forestall antagonistic symptoms, for example, the runs and tooting, due to over the top measure of maturation by colonic microorganisms inside a brief timeframe in neonatal children under stress and at most serious danger of drying out and hypothermia. In light of the research demonstrated above, we chose to utilize inulin in the present study. Poultry hart additionally has a specific organ the ceca at the terminal part of the gastrointestinal tract when offers a nutrients rich environment for a large number of microflora (10^{11} cfu/g, having a place with 200 or more strains). The microflora of the poultry caecum are extensively classified into three: commanding, sub-ruling what's more, impermanent populaces and to profit advantages of synergism from microbial maturation and supplementation of grill weight control plans with prebiotic inulin demonstrated no impact on the weight and estimation of tibia however directly enhanced the relative evident maintenance of Ca, Zn and Cu (Timms, 1968; Barnes, 1979; Ortiz *et al*., 2009). Samanta *et al*., (2012) have said referent expanded the powder substance and Ca substance of tibia in ovens accepting inulin and built up part of prebiotics on change of mineral use and bone mineralization. Inulin, being a prebiotic, is not processed by the poultry's own gastric or pancreatic chemicals but used by the particular gathering of microflora specifically Bifidobacteria and Lactobacilli at the digestive tract for creation of different short chain unsaturated fats and lactic acids.

The utilization of antibiotics is restricted in animal feed, thereby the use of prebiotic which affecting not only animal health. However, prebiotics high security and important in gastroenterology, because prebiotics can have similar effect is to antibiotics but probiotics will thrive and pathogen will decrease. At present in case use prebiotic with probiotic will be safe and effective. Jerusalem artichoke is a good source of prebiotics, specifically inulin, a source of fructo-oligosaccharide (FOS). Jerusalem artichoke can make Bifidobacteria and Lactobacilli to increase in the intestines and reduce pathogen such as clostridium and *Escherichia coli* (Younes *et al*., 1995; Kaur and Gupta, 2002). In combine use of prebiotics with probiotics also called synbiotics, the probiotic will thrive than add only probiotic because they are sub serve together. And more probiotic pass to intestinal (Wanaporn, 2014) this research has purpose for study usage prebiotic with probiotic for increase the carcass quality and meat quality. Synbiotic are a combination of probiotics and prebiotics (Ashraf *et al*., 2013) when could assist the survival of the probiotic organism because preserves substrate is available for fermentation. This could result in advantages to the host through the availability of the live microorganism. The combination of a prebiotic and probiotic in one product has been shown to confer benefits beyond those of either and it may be the combination of synbiotics that beneficially affected the host by improves the survival.

Material and Methods

Animal and Treatments

Four hundred Ross-308 chickens with 42 days old of age (mixed gender), there were 4 groups and 4 replicates (25 chickens per replicate), and were allocated to 4 dietary treatments the control diet (T1), adding symbiotic at; 0.025%, 0.050% and 0.075 % of DM for T2, T3 and T4, respectively.

Sample Collection and Analysis

Animal experimentation and animal husbandry, a vaccination protocol includes mareks disease, gumboro disease, bronchitis disease and newcastle disease during the hatchery stop. And vaccination includes bronchitis and newcastle on day 7 and vaccination gumboro on day 14 of the test, respectively. Feeding broiler starter (1-21 days), 22-23% protein energy 3,200 kcal/k and feeding broiler at first (21-42 days), 20% protein, energy, 3,200 kcal/kg as recommended by the NRC (1994) for providing food and water. Full time (*Ad libitum*) and lighting the house at 23:1 hour.

The head of the Jerusalem artichoke cut into thin strips and then baked at a temperature of 60 ℃ for 72 hours. Before grounding to be powder to do the experiment and microorganisms needed to gastrointestinal (BACTOSAC-P®; *Lactobacillus acidophilus, Lactobacillus plantarum, Pediococcus pentosaceus, Streptococcus faecium, Sacchalomyces cervisiae, Bacillus subtilis and Bacillus lichenifermis*) were used at ratio 1:9 (w/w) at the sources of prebiotic and probiotic, respectively. Supplement in powder form instant food in broiler age range 42 days of test weighing chickens every week save and rate of growth. Parameters such as initial weight, final weight, increase weight, feed intake, average daily gain (ADG) and feed conversion ratios (FCR), were collected at all three stages of the experiment. Record the amount of feed intake of the chicken to keep the intestines and to measure the shape of 20 day chicken's intestines. The detection of bacteria in the digestive tract to influence two kinds of Lactic acid bacteria and *Escherichia coli*, as well as measuring the level of ammonia in the gut that followed the method of Daneshmand *et al*. (2011). Random sampling of feed in the second phase of the trial is to analyze the chemical composition by AOAC (1995) and chickens age of 42 days of fasting six hours, and random 12 chickens per treatment, cutting for examination carcass quality (Jaturasitha, 2010), carcass and cutting percentage and random tender loin for examination pH, cooking loss and drip loss, (Devine, 1999), chemical elements (protein, fat and moisture) (AOAC, 1995) shear force (Van Oeckel *et al*., 1999) and color of meat (Lightness (L*), Redness (a*) and Yellowness (b*) (Jaturasitha, 2010).

Statistical analysis

Data was statistically analyzed according to a Completely Randomized Design (CRD) (SAS, 1996). Significant differences between treatments were determined using Duncan's News Multiple Range Test (DMRT).

Results

The results were showed that supplementation of all three supplements did not effected on Increase weight and average daily gain (ADG), but lower feed conversion ratios (FCR) and feed intake were recorded as; 66.00, 70.65, 74.42 and 70.77 g/day; 2.38, 1.82, 1.74 and 1.79; 166.63, 136.52, 142.30 and 135.19 g/day in T1, T2, T3 and T4 respectively (Table 1). The intestinal histomorphology found that villus height were recorded as; 867.51 µm (T1), 873.27 µm (T2), 908.86 µm (T3) and 877.86 µm (T4) results showed that the higher in synbiotic supplemented 0.050 % of DM, and lowering of ammonia were recorded as; 9.20, 7.95, 6.96 and 11.80 mg/l in T1, T2, T3 and T4 respectively (Table 2) and trend toward lowering in synbiotic supplemented 0.050 % of DM, of *E*.coli (1.3 x10^4) in 21 day.

Table 1. Effects of prebiotic supplemented with probiotic in diets on production performance in broiler

Items	synbiotic levels in rations (%)				SEM	P-value
	0 (n=25)	0.025 (n=25)	0.05 (n=25)	0.075 (n=25)		
Initial weight (g)	131.75	130.31	130.06	130.00	1.514	ns
Final weight (g)	2247.36	2391.07	2422.20	2394.77	3.736	ns
Increase weight (g)	2115.61	2260.80	2291.10	2264.76	3.690	ns
Feed intake (g)	158.30^a	134.02^b	134.30^b	135.19^b	2.598	*
ADG (g)	66.11	70.65	71.60	70.77	1.153	ns
FCR	2.27^a	1.78^b	1.77^b	1.79^b	0.057	*

a,b ,cMeans in row with different superscripts letter are significant differences (P<0.05), ns = non-significant (p>0.05), * = significant

Table 2. Effects of synbiotic supplementation in diets on mucosal histology, population of *Escherichia coli*, Lactic acid bacteria and ammonia concentration in intestinal digesta of broilers

Items	synbiotic levels in rations (%)				SEM	P-value
	0 (*n*=25)	0.025 (*n*=25)	0.05 (*n*=25)	0.075 (*n*=25)		
Villus height (µm)	867.51^a	873.27^a	908.86^b	877.86^{ab}	9.10	*
Cryptal depth (µm)	151.08	154.40	157.38	153.98	3.59	ns
Ammonia (mg/l) 21 d	1.51	1.50	1.02	2.48	0.16	ns
Ammonia (mg/l) 42 d	9.20^b	7.95^{ab}	6.96^a	11.80^c	0.28	*
E.coli (MPN/g) 21 d	7.5	2.5	1.3	7.5	0.11	ns
E.coli (MPN/g) 42 d	2.69	3.31	2.53	2.45	0.14	ns
Lactic acid bacteria ($\log_{10}$) 21 d	8.35	8.19	7.82	8.63	0.09	ns
Lactic acid bacteria ($\log_{10}$) 42 d	7.83	8.22	8.18	7.81	0.11	ns

n = number of broilers, ^{a,b,c}Means in row with different superscripts letter are significant differences (P<0.05), ns = non-significant (p>0.05), * = significant, MPN = most probable number of coliform organisms (*Escherichia coli*) obtain three most probable number table/100 ml, $\log_{10}$ = a logarithm to the base 10 and SEM = Standard error of mean

The effect of synbiotic supplementation on carcass quality and meat quality of broilers the after end of trial 42 day, randomly chickens 20 per experimental unit necropsy digest pieces. There was no statistical difference, but trend toward higher in synbiotic supplemented 0.050 % of DM, of carcass percentage (87.29%). While, visceral fat around the abdomen decreased when chicken fed with synbiotics in diets were recorded as; 2.84, 2.10, 1.42 and 1.41 % in T1, T2, T3 and T4, respectively ($P<0.05$) in Table 3. However, results showed that trend toward lowering in synbiotic supplemented 0.050 % of DM, of water holding capacity (drip loss = 4.17 %) and chemical meat composition (fat = 1.18 %) in Table 4.

Table 3. Effects of synbiotic supplementation in diets on carcass quality in broilers

Items (%)	Synbiotic levels in rations (%)				SEM	P-value
	0 (*n=20*)	0.025 (*n=20*)	0.05 (*n=20*)	0.075 (*n=20*)		
Carcass	83.95	82.48	87.29	84.35	1.14	ns
Breast	23.74	24.10	24.55	24.17	0.35	ns
Thigh	16.72	18.10	18.24	18.58	0.36	ns
Drumstick	12.01	12.35	12.32	12.52	0.31	ns
Wings	10.71	11.67	11.86	11.73	0.19	ns
Tender loin	4.87	4.71	5.14	4.98	0.10	ns
Visceral fat	2.84^{a}	2.10^{ab}	1.32^{b}	1.41^{b}	0.75	*
Entrails %	20.75	18.88	19.38	19.25	1.94	ns
Rib %	21.86	21.93	18.75	19.66	0.59	ns

n = number of broilers, ^{a,b,c}Means in row with different superscripts letter are significant differences ($P<0.05$), ns = non-significant ($p>0.05$), * = significant and SEM = Standard error of mean

Discussion

Results showed that in all treatment groups the supplementation of synbiotic, significantly improved ADG, FCR and feed intake when compared to control diet ($P<0.05$). However, supplementation on all three supplement diets did not affect carcass quality (breast, thigh, drumstick, wings, tender loin, visceral fat, entrails and rib) or meat quality (pH, lightness (L*), redness (a*), yellowness (b*), cooking loss, drip loss, shear force and chemical meat composition). Suparom *et al*. (2013) found that supplementing synbiotic in broiler diet showed that synbiotic improver production performance but no here effect on carcass quality. Probiotic (BACTOSAC®) supplementation in drinking water showed that probiotic supplementation in decreased drip loss in chicken meat ($p<0.05$) (Nopparatmaitree *et al*., 2014). Raksasiri *et al*. (2015) found that prebiotic supplementation (jerusalem artichoke, curcuma white and sago palm) in broiler diets showed that the redness value (a*) of chickens supplemented with Jerusalem artichoke and curcuma white were significantly higher than chickens supplemented with control diet.

Table 4. Effects of synbiotic supplementation in diets on meat quality in broilers

Items	Synbiotic levels in rations (%)				SEM	P-value
	0 (*n=20*)	0.025 (*n=20*)	0.05 (*n=20*)	0.075 (*n=20*)		
pH (1 hr)	6.00	6.04	6.02	6.04	0.07	ns
Color at 24 hour after chill storage at 5 °C						
Lightness (L*)	50.52	49.41	49.59	49.62	0.33	ns
Redness (a*)	1.55	1.84	1.87	1.65	0.05	ns
Yellowness (b*)	4.62	4.60	4.74	4.20	0.27	ns
Water holding capacity						
Cooking loss (%)	28.65	27.15	28.10	27.62	1.59	ns
Drip loss (5 day) (%)	6.97	5.63	4.17	5.57	0.18	ns
Shear force (μ)	2.86	2.72	2.84	2.76	0.16	ns
Chemical meat composition						
Protein (%)	21.42	21.63	21.76	21.71	0.81	ns
Fat (%)	1.72	1.22	1.18	1.13	0.09	ns
Moisture (%)	73.32	75.64	75.13	74.96	1.13	ns

n = number of broilers, ns = non-significant (p>0.05) and SEM = Standard error of mean

The result of morphology of chicken intestines at the age of 42 days dietary supplementation of synbiotics significantly (P<0.05) at 0.05% DM, increased the villus length but there were no significant differences in crypt depth. However, the continuously increasing growth rates and increases feed efficiency from inulin supplementation in the diet can help increase the height of villi and improve morphology thus affecting the absorption of food and nutrient assimilation into the animal. As a result, animal nutrition, can be used in the growing process the movement has increased (Awad *et al*., 2008). However, several researchers reported that dietary supplementation of synbiotic significantly increased the villus length and had no significant effect on crypt depth compared with the control. In addition, Baski and Al-Sardary, (2015) reported that significantly longer villi were recorded for chickens that received 2.5 g/kg synbiotic than for other experimental groups. Morphological data showed that synbiotic or prebiotic supplemented broilers had higher (P< 0.05) jejunal villus height at 28 d of age (Ghasemi and Taherpour, 2013). Mirza (2009) found a significant increase in ileum villus height at 42 days of synbiotic supplementation broiler diet, and several researchers reported significant increases in villus height by dietary probiotics and prebiotics (Awad *et al*., 2009; Samli *et al*., 2007; Houshmand *et al*., 2012; Khodambashi *et al*., 2012; Tsirtsikos *et al*., 2012). Meanwhile, the count of bacteria in the appendix (caecum) found to have lower of levels ammonia (0.673 mg/l) in day 25 and infection of *Escherichia coli* (1.3×10^4) in the intestine in the group has supplemented at a level of 0.05%. The reduction of bacteria was to blame such as Clostridium and *Escherichia coli* makes amount of ammonia in the intestinal tract and in the blood decreased have the effect of inhibiting carcinogens. Fat synthesis in the liver as a result, lipid and cholesterol in the blood decreased (Schijver, 2001; Kaur and Gupta, 2002). Swanson and Fahey (2002) suggested that key role of Bifidobacteria and Lactobacilli groups have enzymes crumble proteins group azoreductase nitroductas nitrate reductase and *β*-glucuronidase low the protein causes these toxins. Synbiotics had beneficial effects on the overall status of the organisms as defined by low mortality and high production parameters and the synbiotic ideas about component of activity: changing the organization of intestinal microbiota by feasible advantage life form and non-absorbable living being substrates (Hozan, 2016; Dunislawska *et al*., 2017). However, the experiment found that ammonia levels at day 42 were decreased caves of group synbiotic supplement at 0.05% as a result of the *Escherichia coli*, the amount of ammonia in the intestine decreased ($P<0.05$).

Accumulation of fat in the muscle at all levels of supplementation increased and also the percentage of weight loss during storage in enhancing the level of 0.05 percent as well. However, Suparom *et al*. (2013) found that adding synbiotic to chicken feed encouraged higher production performance, but did not affect the quality of the carcass. Similar to Nopparatmaitree *et al*. (2014) who reported that prebiotics supplementation in drinking water the results showed that the percentage of weight loss during storage. Raksasiri *et al*. (2015) found that prebiotic supplementation (jerusalem artichoke, curcuma white and sago palm) in broiler diet showed that, the redness value (a*) of chickens supplemented with Jerusalem artichoke and curcuma white were significantly higher than those chickens supplemented with control diet ($p<0.05$) shows the reflection of the red light this represents a value of the accumulation of pigment in clusters of myoglobin or pigments are high and as a consequence the quality of nutrition and found no statistical difference in educational others.

It is concluded that the synbiotics in broiler diet, in the percentage of 0.05 is the amount of feed and the rate of changing feed made the lose weight. This was beneficial to improve production and height of villi and the crypt depth in the intestines. Even though the current study was conducted under non-challenge conditions of broiler diets did not result in changes in performance of birds, meat and carcass quality. Possible mechanisms of action for synbiotics are suggested the stimulation of antimicrobial substances by competition for adhesion to epithelial cells, and stimulated the host's immune system. Supplementation of synbiotics might provide a beneficial immune modulation status.

Acknowledgments

The authors are grateful to research and researcher for industry (RRi) on the Thailand Research Fund (TRF), Suranaree university of technology, Nakhon Ratchasima rajabhat university and K.M.P. BIOTECH CO., LTD.

References

AOAC (1995). Official Method of Analysis. 16th ed. Association of Official Analytical Chemist, Washington, DC.

Apanavicius, C. J., Powell, K. L., Vester, B. M., Karr-Lilienthal, L. K., Pope, L. L., Fastinger, N. D., Wallig, M. A., Tappenden, K. A. and Swanson, K. S. (2007). Fructan supplementation and infection affect food intake, fever, and epithelial sloughing from Salmonella challenge in weanling puppies. Journal of Nutrition 137:1923–1930.

Ashraf, S., Zaneb, H., Yousaf, M. S., Ijaz, A., Sohail, M. U., Muti, S., Usman Ijaz, M. M. S. and Rehman, H. (2013). Effect of dietary supplementation of prebiotics and probiotics on intestinal micro-architecture in broilers reared under cyclic heat stress. Journal of Animal Physiology and Animal Nutrition. 97:68-73.

Awad, W. A., Ghareeb, K., Abdel-Raheem, S. and Böhm, J. (2009). Effects of dietary inclusion of probiotic and synbiotic on growth performance, organ weights, and intestinal histomorphology of broiler chicks. Journal of Poultry Science. 88:49-56.

Awad, W. A., Ghareeb, K. and Böhm, J. (2008). Intestinal structure and function of Broiler chickens on diets supplemented with a symbiotic containing Enterococcus faecium and oligosaccharides. International Journal of Molecular Science. 9:2205-2216.

Barnes, E. M. (1979). The nutritional significance of dietary fiber analysis. Animal Feed Science and Technology. 90:3-20.

Barry, K. A., Hernot, D. C., Middelbos, I. S., Francis, C., Dunsford, B., Swanson, K. S. and Fahey, G. C. (2009). Low-level fructan supplementation of dogs enhances nutrient digestion and modifies stool metabolite concentrations, but does not alter fecal microbiota populations. Journal of Animal Science. 87:4244-4252.

Baski, S. S. M. and Al-Sardary S. Y. T. (2015). Effects of dietary supplementation of prebiotic and synbiotic on broiler chickens hematology and intestinal integrity. Journal of Poultry Science. 14:31-36.

Bosscher, D. (2009). Fructan prebiotics derived from inulin. In Prebiotics and probiotics science and technology. In Charalampopoulos, D. and Rastall, RA. (Eds.), New York, USA: Springer-Verlag. pp. 163-205.

Daneshmand, A., Sadeghi, G. H., Karimi, A. and Vaziry, A. (2011). Effect of oyster mushroom (Pleurotus ostreatus) with and without prebiotic on growth performance and some blood parameter of male broilers. Animal Feed Science and Technology. 170:91-96.

Devine, C. E. (1999). Effect of rigor temperature on muscle shortening and tenderization of restrained and unrestrained beef m. longissimus thoracicusetlumborum. Meat Science. 51:61-72.

De Vrese, M. and Marteau, P. R. (2007). Probiotics and prebiotics: effects on diarrhea. Journal of Nutrition. 137:803-811.

Dunislawska, A., Slawinska, A., Stadnicka, K., Bednarczyk, M., Gulewicz, P., Jozefiak, D. and Siwek, M. (2017). Synbiotics for broiler chickens - *In Vitro* design and evaluation of the influence on host and selected microbiota populations following *In Ovo* delivery. PLoS ONE Tenth Anniversary. 12:e0168587.

Flickinger, E. A., Van Loo, J. and Fahey, G. C. (2003). Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals: a review. Critical Reviews in Food Science and Nutrition. 43:19-60.

Gaggı`a, F., Mattarelli, P. and Biavati, B. (2010). Probiotics and prebiotics in animal feeding for safe food production. International Journal of Food Microbiology. 141:15-28.

Ghasemi, H. A. and Taherpour, K. (2013). Comparative effects of probiotic, prebiotic and synbiotic supplements on performance, jejunal morphology, serum lipid profile and antibody response of broiler chicks. Journal of Life Science and Technology. 1:20-27.

Houshmand, M., Azhar, K., Zulkifli, I., Bejo, M. H. and Ka-myab, A. (2012). Effects of non-antibiotic feed additives on performance, immunity and intestinal morphology of broilers fed different levels of protein. South African. Journal of Animal Science. 42:22-42.

Hozan, J. H. (2016). Synbiotic as Feed Additives Relating to Animal Health and Performance. Advances in Microbiology. 6:288-302.

Jaturasitha, S. (2010). Meat technology. Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Thailand.

Kaur, N. and Gupta, A. K. (2002). Applications of inulin and oligofructose in health and nutrition. Journal of Biological Science. 27:703-714.

Khodambashi, E. N., Samie, A., Rahmani, H. R. and Ruiz-Feria, C. A. (2012). The effect of peppermint essential oil and fructooligosaccharides, as alternatives to virginiamycin, on growth performance, digestibility, gut morphology and immune response of male broilers. Journal of Animal Feed Science and Technology. 175:57-64.

Mirza, R. A. (2009). Using prepared synbiotic in early feeding of broiler chicken and it’s effect on some productive, physiological and histological performance and carcass characteristics. (Master’s Thesis). University of Salahddin-Erbil-Agriculture College. (Arabic).

Nopparatmaitree, M., Lertchunhakiat, K., Sri-onlerd, J. and Kitpipit, W. (2014). Effects of probiotic (Bactosac®) supplementation in drinking water on apparent nutrient digestibility, intestinal histomorphology, carcass percentage and meat quality of broiler chickens. Khon Kaen Agricultural journal. 42:221 - 230.

NRC (1994). Nutrient Requirement of Poultry. 9th ed. Washington, D.C.

Ortiz, L. T., Rodriguez, M. L., Alzueta, C., Reboleand, A. and Trevino, J. (2009). Effect of inulin on growth performance, intestinal tract size, mineral retention, and tibial bone mineralization in broiler chickens. British Poultry Science. 50:425-342.

Propst, E. L., Flickinger, E. A., Bauer, L. L., Merchen, N. R. and Fahey, G. C. (2003). A doseresponse experiment evaluating the effects of oligofructose and inulin on nutrient digestibility, stool quality, and fecal protein catabolites in healthy adult dogs. Journal of Animal Science. 81:3057-3066.

Raksasiri, B. V., Petlum, A., Paengkoum, S., Poonsuk, K., Thitisak, P. and Paengkoum, P. (2015). Effects of jerusalem artichoke, curcuma white and sago palm supplementation in broiler diet on production performance, carcass quality and meat quality. Khon Kaen Agricultural journal. 43:202-207.

Roberfroid, M. B. (2000). Prebiotics and Probiotics: Are They Functional Foods? American. Journal of Clinical Nutrition. 71:1682S-1687.

Saavedra, J. M. (2005). Prebiotics: diet–bacterial–gut interactions and their impact on health. Clinical Nutrition Highlights. 1:2-7.

SAS (1996). User's guide: Statistic, Version 5. Edition., SAS. Inst Cary, CN, USA.

Samanta, A. K., Senani, S., Kolte, A. P., Sridhar, M., Sampath, K. T., Jayapal, N. and Anusuya, D. (2012). Production and in vitro evaluation of xylooligosaccharides generated from corn cobs. Food and Bioproducts Processing. 90:466-474.

Samli, H. E., Senkoylu, N., Koc, F., Kanter, M. and Agma, A. (2007). Effects of enterococcus faecium and dried whey on broiler performance, gut histomorphology and microbiota. Archives of Animal Nutrition. 61:42-49.

Schijver, R. D. (2001). Dietary oligosaccharide supplements: Effects on digestion in pig. Digestive physiology of pig. Proceedings of Alltech's 8th Ann. Symp. Swedish University of Agricultiral Science. Press, Uppsala. pp. 121-123.

Suparom, W., Chumpawadee, S., Santaweesuk, N. and Khajarern, J. (2013). Efficacy of symbiotic in broiler die. Khon Kaen Agricultural Journal. 41:381-387.

Swanson, K. S. and Fahey G. C. (2002). Prebiotics in companion animal nutrition. In Lyons T.P., Jacques K.A. (Eds.) Biotechnology in the feed industry. Proceedings of Alltech's 18th Ann. Symp. Nottingham University Press. Loughborough, U. K. pp. 461-473.

Swanson, K. S., Grieshop, C. M., Flickinger, E. A., Bauer, L. L., Healy, H. P., Dawson, K. A., Merchen, N. R. and Fahey, G. C. (2002). Supplemental fructooligosaccharides and mannanoligosaccharides influence immune function, ileal and total tract nutrient digestibilities, microbial populations and concentrations of protein catabolites in the large bowel of dogs. Journal of Nutrition. 142:980-989.

Timms, I. (1968). Observations on the bacterial flora of the alimentarytract in three age groups of normal chickens. British Veterinary Journal 124:470-477.

Tsirtsikos, P., Fegeros, K., Balaskas, C., Kominakis, A. and Mountzouris, K. C. (2012). Dietary probiotic inclusion level modulates intestinal mucin composition and mucosal morphology in broilers. Journal of Poultry Science. 91:1860-1868.

Van Oeckel, M. J., Warnants N. and Boucqué Ch.V. (1999). Pork tenderness estimation by taste panel, Warner-Bratzler shear force and on-line method. Meat Science. 53:259-267.

Wanaporn, T. (2014). Alternatives to the Use of Antibiotics as Growth Promoters for Livestock Animals. Journal of Agricultural. 30:201-212.

Younes, H., Garleb, K., Behr, S., Rémésy, C. and Demigné, C. (1995). Fermentable fibers or oligosaccharides reduce urinary nitrogen excretion by increasing urea disposal in the rat cecum. Journal of Nutrition. 125:1010-1016.

(Received: 13 September 2018, accepted: 31 October 2018)