ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 2 (3): 214-219, 2003

Effect of Adding Chicory Fructans in Feed on Broiler Growth Performance, Serum Cholesterol and Intestinal Length

Yusrizal and T. C. Chen
Poultry Science Department, Mississippi State University, Mississippi State, MS 39762, USA
E-mail: tcchen@poultry.msstate.edu

Abstract: This study was conducted to evaluate the effectiveness of adding chicory fructans in feed on growth performance, intestinal length and structure of the broiler chicken. Inulin or oligofructose improved (P< 0.05) body weight gain, feed conversion, carcass weight, carcass percentage and increased the gut length of female birds. The beta fructans also reduced (P<0.05) serum cholesterol and abdominal fat of broilers. Inulin as well as oligofructose treated females had a more dense jejunum villi distribution in the small intestine.

Key words: Inulin, oligofructose, performance, intestine, cholesterol

Introduction

The efficiency of broiler growing and feeding programs can be determined by live body weight, feed conversion and the age at which a desire body weight is reached. Usually, as feeding programs become more efficient, feed conversion is improved and the length of time necessary to reach a desired weight decreases. However, growth rate is the most important. To establish a more productive program for raising broilers, it becomes necessary to speed up growth rate (North and Bell, 1990). Rapid growth not only saves labor and feed but also allows the production of more broilers annually; thereby, minimizing many of the fixed costs of production (Austic and Nesheim, 1990).

Prebiotics are health promoting non-digestible food ingredients that affect the host beneficially by selectively stimulating the growth and/or activity of one or many naturally present or introduced bacterial species in the intestine (Gibson and Roberfroid, 1995). Recent research and understanding of probiotics has lead to the development of prebiotics. Prebiotics are not digested by the animal's digestive enzymes and affect the host beneficially by selectively stimulating the growth and/or metabolic activity of one or more naturally present or introduced bacterial species in the intestine (Young, 1998). Normal intestinal microflora such as, *Lactobacilli spp.* or *Bifidobacterium spp.* use inulin or oligofructose this carbohydrate source, such as fructooligosaccharide (FOS), for fermentation more efficiently than other groups of bacteria. Bifidobacteria would have efficient transmembrane transporters for fructooligosaccharides (Crittenden, personal communication, 2001). Bifidobacteria and lactobacilli are considered indicator organisms for a flora which allows good GI functioning of the host. These microorganisms produce short chain fatty acids, creating an acidic environment which suppresses the growth of putrefactive proteolytic bacteria.

Prebiotics have shown the ability to decrease colonization of bacteria such as *E. coli* and *Salmonella,* while increasing the growth of non-pathogenic microorganisms.

Feeding inulin or oligofructose has influenced broiler performance. Ammerman *et al.* (1989) reported that feeding male broilers a 0.375% level of oligofructose produced heavier birds at 47 days and improved percent hot carcass weight and percent breast weight while percent fat pad was lowered. However, Waldroup *et al.* (1993) reported that the addition of oligofructose to nutritionally complete broiler diets at 0.375% had little consistent effect on growth rate, feed utilization, mortality, carcass dressing percentage, abdominal fat content and incidence or severity of salmonella contamination of processed broiler carcasses. These differences could be due to the difference in bird sexes. The use of prebiotics and probiotics in human diets has given researchers the hope that the same effects seen in humans will be seen in poultry. Brighenti *et al.* (1999) and Davidson *et al.* (1998) have shown a reduction in serum cholesterol levels of human volunteers consuming inulin. The cholesterol lowering effect in hamsters (Trautwein *et al.,* 1998) and dogs (Diez *et al.,* 1998) has been shown. Pigs fed probiotics also exhibited a significantly lower level of serum cholesterol (Gilliland *et al.,* 1985). Jin *et al.* (1998) examined the effects of *Lactobacillus* cultures on serum cholesterol levels of poultry. They observed that all diets given to birds containing the cultures significantly lowered the serum cholesterol. The objective of this research was to study the effectiveness of adding chicory beta (2-1) fructans to the diet on broiler growth performance, serum cholesterol and intestinal characteristics.

Materials and Methods

Birds and Diets: Ninety-eight chicks (day old chick) consisting of 48 male and 48 female, hatchery vaccinated (Mareks and IBDV), Ross x Ross strain,

were obtained from Peco Farms in Gordo, Alabama. Birds were assigned to twelve 75x65x35 cm cages with four birds per cage. Four cages male and four cages female were randomly assigned to each of the following treatments:

1. Control feed
2. Feed with 1.0% inulin (Raftifeed® IPF, which was obtained by extracting chicory roots with hot water. It is a beta (2-1) fructan with chain length varying between degree of polymerization (DP) 3 to 60 (The average DP is 9).
3. Feed with 1.0% oligofructose (Raftifeed® OPS, which is a partial enzymatic hydrolysate of chicory inulin and has a DP ranging between 3 and 8 with an average of 4).

Inulin and oligofructose were produced by Orafti, N.V., Belgium. Birds were housed in a room with continuous lighting and maintained at a temperature of 32 °C initially. After two weeks, the temperature was reduced to 24 °C and where it remained for the rest of the feeding period. Chicks had free access to antibiotic-free feed with Starter diets contained 3150 kcal/kg ME and 21.31% crude protein (CP) and grower diets contained 3200 kcal/kg ME and 19.79% CP (Table 1) and water during the 6-week growout period.

Table 1: Composition of experimental broiler basal diets

Ingredient	Starter	Grower
	------- % of diet -------	
Corn	57.55	61.72
Soybean	33.86	30.00
Poultry Fat	4.42	4.45
Dical P(Phosphor Sources)	1.78	1.65
Limestone (Ca sources)	1.34	1.16
NaCl	0.47	0.46
DL-Methionine	0.32	0.24
Vitamin/Mineral	0.25	0.25
L-Lysine HCL	0.01	0.07
Total	100.00	100.00

Starter diet: From 1 to 4 weeks of age (21.31% CP and 3150 kcal ME)
Grower diet: From 4 to 6 weeks of age (19.79% CP and 3200 kcal ME)

Analyses

Broiler Performance: Body weights were recorded weekly. Feed intake was monitored and feed conversion ratio (feed:weight gain) was calculated by totaling the amount of feed consumed divided by the body weight gain of the birds (Smith, 1999).

Bird Processing: At the end of the experiment (6 weeks), birds were weighed individually and transferred to a processing plant. Those birds were killed, bled, scalded and defeathered. Then the New-York dressed carcasses were transferred to the lab for abdominal fat and gut length measurements. After obtaining the measurements, carcasses were eviscerated and the head, neck and feet removed for RTC (ready-to-cook) carcass weight determination. Carcass percentages were calculated by dividing the RTC weight by the live bird weight and multiplied by 100.

Gut length and Abdominal Fat Content: Abdominal fat content was measured by removing and weighing all fat tissues surrounding the gizzard and adjacent to abdominal fat muscle (Kubena *et al.* 1974). Gut length was measured by measuring the length of small and large intestines.

Scanning Electron Microscopy: About two-centimeter length jejunum sections were removed from each broiler intestine and immersed in formaldehyde preservative. The samples were then treated with 0.1 M. phosphate buffer at pH 7.0 for 15 min and rinsed three times with distilled water (each time for 15 min). The rinsed samples were fixed in 1% glutaraldehyde and post-fixed in osmium tetra oxide. Specimens were dehydrated in a graded series of ethanol and dried in a Bomar SPE-900EX critical point dryer attached to a carbon dioxide tank. The critical point dried samples were then coated with gold and examined with an Hitachi HHS-2R scanning electron microscope (Chen and Stinson, 1983).

Serum cholesterol: Blood samples were collected from four males and four females, separately, of each treatment at 5 week of age. Blood cholesterol levels were measured with a KODAK, Ektachem DT 60 Analyzer (Eastman Kodak Company, Rochester, N.Y.). Two to three milliliters of blood were collected from the brachial vein in the wing. About 2 ml of the blood was transferred into non-anticoagulant centrifuge tubes and allowed to sit for about 1 hr. The sample tubes were then centrifuged to separate serum and blood cells. Serum cholesterol contents were analyzed.

Statistical Analysis: The design for this experiment was a Completely Randomized Design (CRD) with four replications. Data were analyzed with the Analysis of Variance (ANOVA) procedure of Statistical Analysis System (SAS/STAT, 1990). When significant differences ($P<0.05$) were detected, the least significant difference (LSD) test was used to separate the mean values (Steel and Torrie, 1980).

Results and Discussion

Broiler Performance: Adding 1% oligofructose or 1% inulin had no effect ($P>0.05$) on body weight, RTC (ready-to-cook) carcass weight, feed:gain ratio and gut length of male birds. However, the carcass percentages of the inulin males were higher ($P<0.05$)

Table 2: Body weight, carcass weight, carcass percentage, feed to gain ratios and gut length of broiler as affected by inulin and oligofructose supplementations

Variable Parameter	Male			Female		
	Control	Inulin	Oligofructose	Control	Inulin	Oligofructose
Body weight (g)	2210.79a	2180.66a	2262.35a	1972.81a	1986.53a	2176.22b
Carcass weight (g)	1488.09a	1485.75a	1518.38a	1310.80a	1337.82a	1482.13b
Carcass %	66.69a	68.11b	67.09ab	66.36a	66.92ab	68.05b
Feed:gain	1.84a	1.89a	1.83a	1.93b	1.95b	1.78a
Gut length (cm)	180.32a	179.39a	186.96a	172.04a	180.43ab	185.63b
Correlation between body weight and gut length regardless treatment		R=0.68			R=0.74	

Each mean represents four observations. Mean of each sex group within a row not followed by a common letter are significantly different (P<0.05).

Table 3: Weekly body weight (g) of broiler as affected by inulin and oligofructose supplementation

Week	Male			Female		
	Control	Inulin	Oligofructose	Control	Inulin	Oligofructose
1	134.27a	147.27a	137.99a	137.95a	143.78a	136.88a
2	432.87a	477.81c	453.25b	427.84a	437.97a	440.30a
3	759.93a	806.65a	791.68a	751.03a	752.67a	783.75a
4	1317.75a	1350.03a	1349.25a	1252.65a	1267.00a	1336.15a
5	1702.88a	1785.81a	1803.31a	1621.53a	1612.33a	1717.85a
6	2310.79a	2180.66a	2262.35a	1972.81a	1986.53a	2176.22b

Each mean represents four observations. Mean of each sex group within a row not followed by a common letter are significantly different (P<0.05).

Table 4: Feed to gain ratio (weekly) of broiler as affected by inulin and oligofructose supplementation

Week	Male			Female		
	Control	Inulin	Oligofructose	Control	Inulin	Oligofructose
1	1.29a	1.23a	1.29a	1.26a	1.24a	1.33a
2	1.35b	1.28a	1.31ab	1.36b	1.33ab	1.31a
3	1.35a	1.43a	1.42a	1.36a	1.48a	1.40a
4	1.99a	2.04a	1.96a	1.96a	1.97a	1.83a
5	1.99a	1.89a	1.82a	2.00b	2.08b	1.74a
6	1.98a	2.33b	2.13ab	2.50b	2.35ab	2.05a

Each mean represents reading from four cages (4 birds/cage). Mean of each sex group within a row not followed by a common letter are significantly different (P<0.05).

Table 5: Serum cholesterol and abdominal fat content of broiler as affected by inulin and oligofructose supplementation

Variable Parameter	Male			Female		
	Control	Inulin	Oligofructose	Control	Inulin	Oligofructose
Serum cholesterol (g/dL)	140.25b	96.00a	96.00a	128.50b	107.00a	103.00a
Abdominal fat (% Carcass)	2.65b	1.80a	2.24ab	3.35b	2.34a	2.34ab
Abdominal fat (% live weight)	1.73b	1.22a	1.50ab	2.20b	1.55a	1.76ab

Each mean represents four observations. Mean of each sex group within a row not followed by a common letter are significantly different (P<0.05).

than those of the controls, which indicates a higher RTC-dressing yield (Table 2). Patterson (1997) reported that there were no dietary effects of ketoses treated birds on weight gain, feed conversion as compared to control.

Adding 1% oligofructose increased (P<0.05) body weights, carcass weights, carcass percentages and gut length of the female birds. The feed:gain ratio was

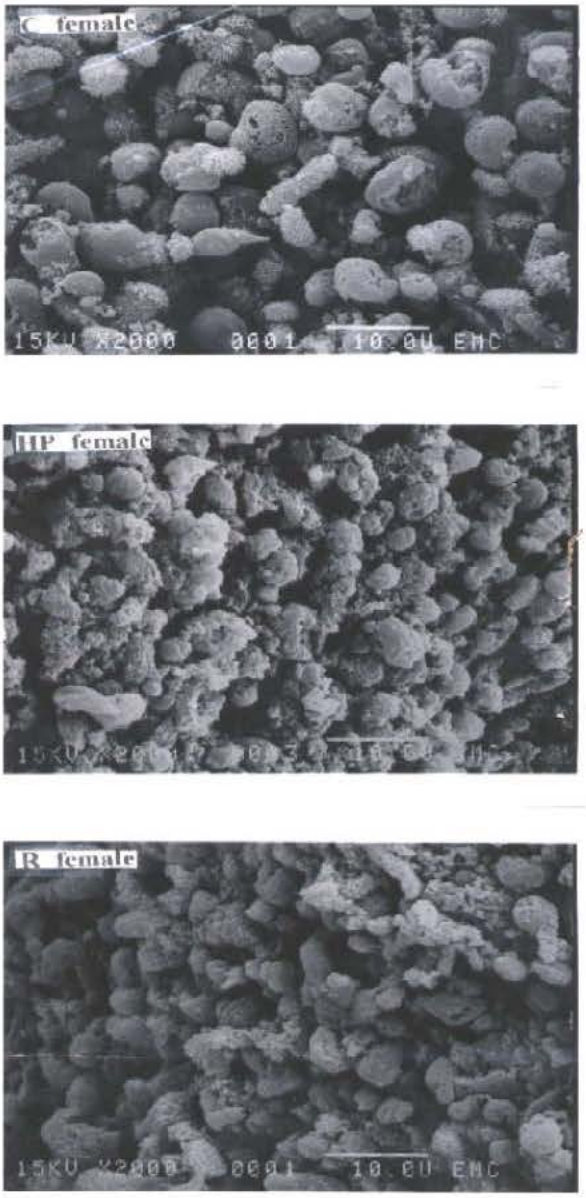

Fig. 1: Scanning electron microscopy of small intestinal of female broiler: C, control; HP, inulin; R, oligofructose

also improved ($P<0.05$) (Table 2 and 4). This increase of body weight averaging more than 10% should be of interest to the poultry industry. Sturkie (1986) reported that female birds appear to be more sensitive to galactose than are males.

Further analyses indicated that most of the increase in female body weight occurred between 5 and 6 week for the oligofructose treatment (Table 3). Waldroup *et al.* (1993) reported that the addition of 0.375% FOS in the diet had little consistent effect on growth rate, feed utilization, mortality, carcass dressing percentage and abdominal fat content of broilers. They did not analyze their data according to bird sexes. Patterson *et al.* (1997) reported that there were no ketoses oligosacharide (glucose, sucrose and fructose) effects on weight gain, feed conversion (feed to gain ratio). On the other hand, positive results of prebiotic on body weight gain, feed gain ratio and carcass weight have been reported. Terada *et al.* (1994) indicated that chickens receiving lactosucrose showed slightly greater body weight gains and improved feed efficiency. Ammerman *et al.* (1989) reported that the FOS treatment at the 0.375% level produced heavier birds and improved carcass weight and percent breast meat. Earlier, Ammerman (1989) reported the addition of fructooligosacharide significantly improved feed efficiency over the entire feeding period of 46 days.

Gut Length and Intestine Characteristics: Regardless of the treatments, the correlation coefficients between broiler gut length and body weight in this study were 0.68 and 0.74 for the male and female birds, respectively. Results suggested that the longer gut length, the better in nutrient absorption which resulted in a heavier body weight. There is a trend to have a longer gut length for the oligofructose treated birds, especially for the females (Table 2). Many reports and research have supported the idea that the use of prebiotics can lengthen villi within the gut and also influence the length of the gut (Parker, 1974; Fuller, 1989; Goldin, 1998; Sanders, 1999).

The scanning electron micrograph indicated that there was no visible difference in villi density among the males, regardless of the treatments. However, the villi from inulin and oligofructose treated birds appear to be more dense (more compact) than those of the controls (Fig. 1). This phenomena may be due to the tropic effect of short chain fatty acids (SCFA), especially butyric acid, that could stimulate the growth of color ectal and ileal mucosal cells. Kripke *et al.* (1989) reported that in rats, SCFA stimulated the growth of color ectal and ileal mucosal cells when they were delivered colorectally or intra peritoneally. Terada *et al.* (1994) reported that the butyric acid was significantly higher in the cecal when broilers were fed 0.15% lactosucrose group, than in the control group and the SCFA supplementation retarded the mucosal atrophy seen after massive bowel resection in rats (Koruda *et al.*, 1990). Feeding diets high in fermentable carbohydrates to rats also promoted the ileal growth and raised ileal and cecal glucagons-like peptide-1 mRNA levels (Reimer and McBurney, 1996). Sakata and Yajima (1984) demonstrated in rats that intraluminally infused Volatile Fatty Acid (VFA) accelerated the cript cell production rate and increased the gut-wall mass. The stimulation was most efficient with butyrate.

Serum Cholesterol: Adding inulin or oligofructose reduced (P<0.05) serum cholesterol for the male and female broilers (Table 5). The decrease in cholesterol level could be due to the cholesterol assimilation (or uptake) by the *Lactobacilli* or to the coprecipitation of cholesterol with deconjugated bile salts (Gilliland *et al.*, 1985). Jin *et al.* (1998) reported that serum cholesterol level in broilers was significantly lower in broilers fed a diet containing the *Lactobacillus* culture. Similar results have been reported by Mohan *et al.* (1996); Tortuero (1973). It also could be a systemic effect. There is an increased production of shot chain fatty acid such as propionate, which is able to interfere with liver metabolism in the liver (Fiordaliso *et al.*, 1995).

Abdominal Fat: It appears that feeding oligofrcutose or inulin resulted in lower abdominal fat for the broilers and the difference was significant (P< 0.05) for the inulin treatment (Table 5). Results agreed with Ammerman *et al.* (1989), who reported that the percentages of fat pad was lower for the broilers fed diets containing 0.375% FOS. Deposits of fat in the abdominal area of the broiler are considered a waste by the poultry industry. Not only is abdominal fat a loss, it also represents an added expense for the processing effluent treatment. In further processing, it appears that the larger the quantity of abdominal fat, the lower the processing yields.

Conclusions: Supplementing broiler diets with oligofructose improved (P< 0.05) body weight gain, feed conversion, carcass weight, carcass percentage and increased the small intestine length for female birds. It appeared that the chicory fructan fed birds also had a more developed small intestine (size) than the control birds. Oligofructose treated females had a more dense ileal villi distribution in the small intestine. An increased intestinal absorption capacity could be at the basis of the improved zootechnical performance of the inulin or oligofructose fed birds. Both inulin and oligofructose reduced (P<0.05) serum cholesterol and abdominal fat on broilers.

References

Ammerman, E., C. Quarles and P. V. Twining, Jr., 1989. Evaluation of fructooligosaccharides on performance and carcass yield of male broilers. Poult. Sci., 68 (Suppl.): 167.

Austic, R. E. and M. C. Nesheim, 1990. Poultry Production. 13th ed. Lea & Febiger 200 Chesterfield Parkway, Malvern, PA.

Brighenti, F. B., M. C. Casiraghi, E. Canzi and A. Ferrari, 1999. Effect of consumption of a ready-to-eat breakfast cereal containing inulin on the intestinal milieu and bloodlipids in healthy male volunteers. Eur. J. Clin. Nutr., 53: 726-733.

Chen, T. C. and R. S. Stinson. 1983. Scanning microscope studies on chicken gizzard structure as affected by cooking. Poult. Sci., 62: 2011-2016.

Davison, M. H., K. C. Maki, C. Synecki, S. A. Torri and K. B. Drennan, 1998. Effects of dietary inulin on serum lipids in men and women with hypercholesterolemia. Nutr. Res., 18: 503-517.

Diez, M., J. L. Homick, P. M. Baldwin, C. Van Eenaeme and L. Istasse, 1998. The influence of sugar beet fiber, guar gum and inulin on nutrient digestibility, water consumption and plasma metabolites in healthy beagle dogs. Res. Vet. Sci., 64: 91-96.

Fiordaliso, M., N. Kok, J. P. Desager, F. Goethals , D. Deboyser, M. Roberfroid and N. Delzenne, 1995. Dietary oligofructose lowers triglycerides, phospholipids and cholesterol in serum and very low density lipoproteins of rat. Lipids, 30: 163-167.

Fuller, R., 1989. Probiotics in man and animals. J. Appl. Bacteriol., 66: 365-378.

Gibson, G. R. and M. B. Roberfroid, 1995. Dietary modulation of the human colonic microflora: introducing the concept of prebiotics. J. Nutr., 125: 1401-12

Gilliland, S. E., C. R. Nelson and C. Maxwell, 1985. Assimilation of cholesterol by *Lactobacillus acidophilus*. Appl. Environ. Microbiol., 49: 377-381.

Goldin, B. R., 1998. Health benefits of probiotics. Br. J. Nutr., 80: 203-207

Jin, L. Z., Y. W. Ho, N. Abdullah and S. Jalaludin, 1998. Growth performance, intestinal microbial populations and serum cholesterol of broiler fed diets containing *Lactobacillus* culture. Poult. Sci., 77: 1259-1265.

Koruda, M. J., R. H. Rolandelli, D. Zimmaro-Bliss, J. Hasting and R. G. Settle, 1990. Parental nutrition supplemented with SCFA: effect on the small bowel mucosa in normal rats. Am. J. Clinic. Nutr., 51: 685-689.

Kripke, S. A., A. D. Fox, J. M. Berman, R. G. Settle and J. L. Rombeau, 1989. Stimulation of intestinal mucosal growth with intra colonic infusion of short chain fatty acids. J. Parent Enteral Nutr., 13: 109-116.

Kubena, L. F., J. W. Deaton, T. C. Chen and F. N. Reece, 1974. Factors influencing the quantity of abdominal fat in broilers. I. Rearing temperature, sex, age or weight and dietary choline chlorine and inositol supplementation. Poult. Sci., 53: 211-214.

Mohan, B. R., A. Kadirvel, A. Natarajan and M. Bhaskaran, 1996. Effect of probitoic supplementation on growth, nitrogen utilization and serum cholesterol in broilers. Br. Poult. Sci., 37: 395-401.

North, M. O. and D. D. Bell, 1990. Commercial Chicken Production Manual. 4th ed. Chapman & Hall, One Penn Plaza, New York, NY.

Parker, R. B., 1974. Probiotics, the other half of antibiotic story. Anim. Nutr. and Health, 29: 4-8.

Patterson, J. A., J. I. Orban, A. L. Sutton and G. N. Ricards, 1997. Selective enrichment of *Bifidobacteria* in the intestinal tracts of broilers by thermally produced kestoses and effect on broiler performance. Poult. Sci., 76: 497-500.

Reimer, R. A. and M. I. McBurney, 1996. Dietary fiber modulates intestinal progulacon massager ribonucleic acid and postprandial secretion of glucagon-like peptide-1 and insulin in rats. Endocrinol., 137: 3948-3956.

Sakata, T. and T. Yajima, 1984. Influence of short chain fatty acids on the epithelial cell division of digestive tract, Q. J. Physiol., 69: 639-648.

Sanders, M., 1999. Probiotics. Food Tech., 53: 67-77.

SAS Institute, 1990. SAS/STAT User's Guide. Release 6.12 Edition. SAS Institute, Inc., Cary, NC.

Smith, T. W., 1999. Commercial Broiler Production. Mississippi State University, Mississippi State, MS. Chap 2, P: 7-13.

Steel, R. G. D. and J. H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd Ed. McGraw-Hill Book Co., New York, NY.

Sturkie, P. D., 1986. Avian Physiology. 4th ed. Springer-Verlag New York Inc. New York, NY.

Terada, A., H. Hara, J. Sakamoto, N. Sato, S. Takagi and T. Mitsuoko, 1994. Effect of dietary supplementation with lactosucrose on cecal flora, cecal metabolites and performance in broiler chicken. Poult. Sci., 73: 1663-1672.

Tortuero, F., 1973. Influence of *Lactobacillus acidophilus* in chicks on the growth, feed conversion, malabsortion of fats syndrome and intestinal flora. Poult. Sci., 52: 197-203.

Trautwein, E. A., D. Rieckhoff and H. F. Erbersdobler, 1998. Dietary inulin lowers plasma cholesterol and triacylglycerol and alters biliary bile acid profile in hamsters. J. Nutr., 128: 1937-1943.

Waldroup, A. L., J. T. Skinner, R. E. Hierholzer and P.W. Waldroup, 1993. An evaluation of fructoolligosaccharide in diets for broiler chickens and effects on *Salmonellae* contamination of carcasses. Poult. Sci., 72: 643-650.

Young, J., 1998. European market developments in prebiotic and probiotic containing foodstuffs. Br. J. Nutr., 80: 231-233.