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Effects of Insoluble Fiber on Serum Biochemical Characteristics in Broiler

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ABSTRACT

An experiment was conducted to determine the effects of insoluble raw fiber concentrate (IRFC) on blood biochemical values in broiler males. Four dietary treatments with three replicates containing 0, 0.25, 0.50 and 0.75% of IRFC were fed to 180 day old Lohmann chicks from 1 to 42 days. The chicks were randomly assigned to 12 cages (15 birds per cage). The experimental period was 42 days and serum biochemical values containing triglyceride, cholesterol, HDL, LDL, VLDL, total protein, albumin, amylase, lipase, calcium and phosphorous were measured at the end of starter (21 d) and grower (42 d) periods. Levels of total protein, albumin, amylase, lipase and phosphorous were not affected much by dietary treatments at day 42. Triglyceride, HDL and VLDL levels affected ($p<0.01$) by different levels of IRFC in diet and they were lower levels in triglyceride and VLDL and higher levels in HDL in 0.50 and 0.75 dietary groups than control and 0.25 groups, also cholesterol and LDL levels in 0.75 group were significantly lower ($p<0.01$) as compared to control group. Levels of total protein, albumin, amylase, lipase and phosphorous did not affected by dietary treatments but Ca in 0.50 group was higher than controls.

Key Words: Insoluble fiber; Serum biochemical; Diet; Broiler

INTRODUCTION

Dietary fiber can be defined as component of plants, which is resistant to digestion by endogenous enzymes. The functional fiber refers to isolated, extracted, or synthetic fiber that has proven health benefits, with several physiological functions (Bersamin & Zidenberg-Cherr, 2004). Most insoluble fibers are moderately or slowly fermented. Those highly resistant to fermentation include isolated cellulose and lignin. Lignin is not fermented due to its composition as a phenyl propane polymer rather than carbohydrate (Whiteley *et al.*, 1996; Klurfeld, 1999). Carbohydrates common in poultry diets are starch, sugars, cellulose and other non-starch compounds. Cellulose and non-starch compounds are typically classified as crude fiber (Wilson & Beyer, 2000).

The major chemical component important to the structural integrity of grains is the insoluble fiber, which makes up the main part of the cell wall architecture. Indeed, insoluble fiber itself has shown beneficial effects on nutrient digestion (Svihus & Hetland, 2001; Hetland *et al.*, 2005). Dietary fiber (DF) content, have an important place in the well-balanced diets. Differentiation of water-soluble and insoluble fiber components has helped elucidate the physiological effects of fiber (Newman *et al.*, 1992).

Fiber is a nutritionally, chemically and physically heterogeneous material. This heterogeneous mix can be categorized into two major subclasses i.e., soluble, viscous and fermentable fiber (soluble) and insoluble, no viscous and no fermentable fiber (insoluble). The two subclasses have different roles in the digestive/absorptive processes within the gastrointestinal tract. The ratio of insoluble to soluble fiber (I: S) in a DF source can affect overall diet utilization and appears to be important in the formulation of diets to provide optimal efficacy (Burhalter *et al.*, 2001).

It is well established that the ingestion of some types of dietary influence lipid levels (Razdan & Pettersson, 1994; Durdi & Gharejeh, 2001). Structural differences between fibers have been reported (Woodward *et al.*, 1988; Jeraci & Lewis, 1999). These include differences in molecular weight (Cui, 2001) and solubility (Aman & Graham, 1987) but the cholesterol-lowering properties are approximately equivalent (Delaney *et al.*, 2003).

The non-digestible carbohydrates (dietary fiber) have been reported to improve the intestinal absorption of minerals, presumably because of their binding or sequestering action (Roberfroid *et al.*, 2002; Coudray *et al.*, 2003). Roberfroid (2000) indicated that a higher concentration of short-chain carboxylic acids resulted from the colonic fermentation of non-digestible carbohydrates, accelerating the colonic absorption of minerals, particularly calcium (Ca^{2+}) and magnesium (Mg^{2+}). The objective of this study was to determine the effect of different levels of IRFC on serum biochemical broiler.

MATERIALS AND METHODS

Birds and diets. The experiment was carried out in a

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completely randomized design using 180 days-old broiler chicks (Lohmann) were weighted and distributed randomly to 4 treatments with 3 replicates (15 chicks in each replicate per pen). Experimental diets, formulated according to NRC (1994), included following levels of Insoluble raw fiber concentrate (IRFC): a) control diet (no IRFC), b) 0.25%, c) 0.50% and d) 0.75% from Vitacel R200 (Table I). Birds were fed with experimental diet for starter (0-21 d) and grower (22-42 d) periods (Table I).

Samples procedures. At days 21 and 42, 2 chicks from each pen were selected and blood samples collected. The analysis of serum, triglyceride (TG), cholesterol (CHOL), high density lipoprotein (HDL), total protein (TP), albumin (ALB), amylase (AML), lipase (LIP), Ca^{2+} and Phosphorous (P), were measured on autoanalyzer (ALCYON 300-Abbott, USA) using commercially available kits. Low density lipoprotein cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) levels were estimated with Friedewald *et al*. (1972) equation.

Statistical analysis. Data were subjected to analysis of variance and significant differences observed in means subjected to Duncan's multiple range test. All data were analyzed for variance analysis using the general linear model (GLM) procedures of the SAS Institute (SAS Institute, 2003).

RESULTS AND DISCUSSION

At day 21, serum TG, CHOL, HDL, LDL, VLDL levels were not influenced by different levels of IRFC in diet, but levels of all this parameters were significantly ($p < 0.01$) affected by levels of IRFC in dietary groups at day 42 (Table II). Serum TG levels were significantly lower in broilers fed diets containing 0.50% IRFC and 0.75% IRFC. Result showed that in 0.75% IRFC group a reduction in serum CHOL and LDL in compare with control group. Also higher concentrations of HDL and lower concentrations of VLDL observed in the serum of 0.50% IRFC and 0.75% IRFC dietary groups. Bile lipids compositions in mammals are mainly phospholipids and cholesterol but poultry contains cholesterol esters and triglycerides. According the Leeson *et al.* (1997) excretion of these lipids may be have a regulatory effects and this can describe the reduction of triglyceride levels with using IRFC due to ability of fibers to binding with lipid compositions.

A negative correlation exists between dietary fiber content and serum cholesterol level (Stasse Wolthuis *et al.*, 1980; Petterson & Aman, 1992; Sundberg *et al.*, 1995). Moundras *et al.* (1997) reported that the plasma cholesterol lowering effect of crude fiber may be due to its ability to enhance fecal excretion of cholesterol and bile acids. Daggy *et al*. (1997) reported that the fiber induces both enhanced

Table I. Composition of experimental diets (%)

Ingredient and composition	Starter (0-21 d)				Grower (22-42 d)			
	1	2	3	4	1	2	3	4
Ground yellow corn	63.85	63.70	63.74	63.49	69.36	69.26	69.12	68.93
Soybean meal (48% CP)	27.00	27.00	26.86	26.90	24.75	24.58	24.47	24.40
Fish meal, menhaden (60% CP)	6.00	5.9	6.00	5.95	2.86	2.88	2.88	2.90
DCP	1.00	1.00	0.82	0.84	0.80	0.80	0.80	0.80
Oyster shell	1.20	1.20	1.13	1.12	1.32	1.32	1.32	1.32
Sodium chloride	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin premix [1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix [2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10
L-lysineHCL	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.05
Coccidiostats	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
IRFC [3]	0.00	0.25	0.50	0.75	0.00	0.25	0.50	0.75
Calculated analysis								
ME, kcal/kg	2910	2900	2900	2895	2960	2950	2940	2935
CP (N × 6.25)	20.91	20.84	20.84	20.81	18.50	18.43	18.37	18.34
ME/CP	139.1	139.1	139.1	139.1	160.0	160.0	160.0	160.0
Crude fiber	3.34	3.51	3.69	3.84	3.28	3.45	3.62	3.79
Ether extract	3.21	3.19	3.20	3.19	3.10	3.10	3.09	3.09
Lysine	1.16	1.16	1.16	1.16	1.02	1.02	1.01	1.00
TSAA	0.90	0.90	0.90	0.90	0.73	0.73	0.72	0.72
Ca^{2+}	1.07	1.06	1.00	1.00	0.9	0.9	0.9	0.9
Available P	0.48	0.48	0.45	0.45	0.36	0.36	0.36	0.36
Ca^{2+}:P ratio	2.22	2.21	2.22	2.22	2.50	2.50	2.50	2.50

1 The vitamin premix supplied the following per kilogram of complete feed: vitamin A, 4,500 IU (retinyl acetate); cholecalciferol, 1,000 IU; vitamin E, 25 IU (dl-a-tocopheryl acetate); vitamin B12, 0.02 mg; menadione, 1.5 mg; riboflavin, 3 mg; thiamine, 1.5 mg; pantothenic acid, 5 mg; niacin, 20 mg; choline, 150 mg; folic acid, 0.5 mg; biotin, 0.5 mg; pyridoxine, 2.5 mg.

2 The mineral premix supplied the following per kilogram of complete feed: manganese ($MnSO_4 \cdot H_2O$), 60 g; zinc (ZnO), 40 mg; iron ($FeSO_4 \cdot 7H_2O$), 80 mg; copper ($CuSO_4 \cdot 5H_2O$), 8 mg; selenium (Na_2SeO_3), 0.2 mg; iodine (Iodized NaCl), 0.8 mg; cobalt ($CoCl_2$), 0.4 mg.

3 IRFC: Insoluble raw fiber concentrate type Vitacel R200 is a commercial product of JRS Co. (Germany) with this composition, DM: 93.9%, crude fiber 72.5%, ADF: 86.5%, ADL: 0.6%, NDF: 90.5%, crude protein (n × 6.25): 1.1%, crude fat 0.2%, NFE: 19.8%, crude ash 0.3%, sugar: <0.1%, crude starch: <0.1%.

Table II. Blood serum lipids of chickens fed different levels of IRFC (mg dL^{-1})

Diet	Serum lipids[1]									
	Triglyceride		Cholesterol		HDL		LDL		VLDL	
	21 d	42 d	21 d	42 d	21 d	42 d	21 d	42 d	21 d	42 d
0.00% IRFC	90.8	106.6^{a}	144.6	143.5^{a}	32.0	33.8^{b}	94.5	88.5^{a}	18.1	21.3^{a}
0.25% IRFC	83.6	100.2^{a}	146.3	135.3^{b}	29.0	34.0^{b}	100.0	81.3^{ab}	16.7	20.1^{a}
0.50% IRFC	83.5	80.8^{b}	132.3	129.3^{bc}	32.0	38.4^{a}	83.6	74.8^{bc}	16.7	16.2^{b}
0.75% IRFC	83.3	75.8^{b}	134.6	123.3^{c}	42.0	39.5^{a}	76.0	68.3^{c}	16.6	15.2^{b}
SEM [2]	2.51	4.48	3.20	2.53	2.09	2.86	4.04	2.56	0.50	0.90
Source of Variance					Probabilities					
Diet	NS	**	NS	**	NS **		NS	**	NS	**

[1] n = 6 samples within each treatment group.
[2] SEM, based on pooled estimate of variance and n = 3.
[a,b]Means within columns with no common superscript differ significantly (P < 0.05) by Duncan's multiple range test.

Table III. Blood serum proteins of chickens fed different levels of IRFC

Diet	Serum proteins[1]			
	Total protein		Albumin	
	21 d	42 d	21 d	42 d
	(g dL^{-1})			
0.00% IRFC	3.30	3.51	1.86	1.91
0.25% IRFC	3.30	3.81	1.93	2.06
0.50% IRFC	3.53	4.01	1.90	2.15
0.75% IRFC	3.65	3.65	1.86	2.18
SEM [2]	0.08	0.08	0.02	0.04
Source of Variance		Probabilities		
Diet	NS	NS	NS	NS

[1] n = 6 samples within each treatment group.
[2] SEM, based on pooled estimate of variance and n = 3.
[a,b]Means within columns with no common superscript differ significantly (P < 0.05)

Table IV. Blood serum enzymes of chickens fed different levels of IRFC

Diet	Serum enzymes[1]			
	Amylase		Lipase	
	21 d	42 d	21 d	42 d
	(µg L^{-1})			
0.00% IRFC	754.7	1270.0	129.3	181.1
0.25% IRFC	803.7	1221.5	149.7	192.0
0.50% IRFC	904.0	1346.3	153.3	188.2
0.75% IRFC	759.0	938.5	135.3	182.5
SEM [2]	36.59	79.23	4.39	7.31
Source of Variance		Probabilities		
Diet	NS	NS	NS	NS

[1] n = 6 samples within each treatment group.
[2] SEM, based on pooled estimate of variance and n = 3.
[a,b]Means within columns with no common superscript differ significantly (P < 0.05)

liver excretion and diversion of intestinal steroids to the feces. Durdi and Gharejeh (2001) reported that reduction in total cholesterol concentration and increased HDL to total cholesterol ratio is probably cause by enhanced reverse cholesterol transport in response to intestinal loss of dietary fat. Mathlouthi *et al.* (2002) reported that indigestible polysaccharides can act directly by increasing bile acid excretion. Garcia-Diez (1996) and Adrizal and Ohtani (2002) confirmed that non-starch polysaccharides have

Table V. Blood serum minerals of chickens fed different levels of IRFC

Diet	Serum minerals[1]			
	Calcium		Phosphorous	
	21 d	42 d	21 d	42 d
	(mg dL^{-1})			
0.00% IRFC	9.40	8.63^{c}	5.63	5.15
0.25% IRFC	9.60	8.68^{bc}	5.16	5.18
0.50% IRFC	9.60	9.23^{a}	5.53	5.91
0.75% IRFC	10.13	9.13^{ab}	5.16	5.66
SEM [2]	0.14	0.10	0.18	0.13
Source of Variance		Probabilities		
Diet	NS	*	NS	NS

[1] n = 6 samples within each treatment group.
[2] SEM, based on pooled estimate of variance and n = 3.
[a,b]Means within columns with no common superscript differ significantly (P < 0.05)

binding property with bile acids. This results in increased fecal and reduced serum cholesterol. Reduction in cholesterol parameter cause increase in HDL and reduce LDL and VLDL in serum. Serum concentrations of total protein (TP), albumin (AL) (Table III) and levels of amylase (AML) and Lipase (LIP) in serum (Table IV) had no significant differences ($p > 0.05$) at days 21 and 42. Levels of phosphorous in serum were not affected ($P > 0.05$) by dietary treatments at days 21 and 42. Besides this, serum Ca^{2+} concentration did not show any differences at day 21 but it was significantly ($P < 0.05$) affected at day 42 (Table V). At day 42 birds fed 0.50% IRFC in diet had higher levels of Ca^{2+} in serum compared with controls. In concurrence with these findings, Roberfroid (2000), Coudray *et al*. (2003) and Chen and Chen (2004) reported that a higher concentration of short-chain carboxylic acids resulting from the colonic fermentation of non-digestible carbohydrates accelerates the colonic absorption of minerals, particularly Ca^{2+} and Mg^{2+}. It seems that this procedure help increasing Ca^{2+} levels in serum.

CONCLUSION

Increase of dietary fiber level resulted in improves the performance and reduces TG, CHOL, LDL, VLDL concentrations in serum of broiler.

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