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The Replacement of Corn with Wheat Screening in Very Young Broiler Chicks

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Abstract: An experiment was conducted to investigate the effect of replacement of corn with different levels of wheat screening and enzyme cocktail on performance, blood parameters, gastrointestinal parameters and gut morphology of very young broiler chicks (0-10 d). Five hundred day old male chickens were randomly assigned to 10 diets. Diets were formulated to have five different levels of wheat screening (0, 6, 12, 18 and 24%) with/without xylanase-glucanase enzyme. Each diet was fed to five groups of ten chicks each. There was not a significant difference in feed intake (FI) of birds fed diets with different levels of wheat screening for first days of life. Body weight gain (BWG) decreased ($P<0.05$) and feed conversion ratio (FCR) increased ($P<0.01$) significantly with increasing wheat screening level in diets. Enzyme supplementation significantly ($P<0.01$) increased BWG and decreased FCR ($P<0.05$). The levels of wheat screening did not have a significant effect on gastrointestinal tract weight whereas the enzyme supplementation significantly ($P<0.01$) decreased weight of gastro intestinal tract including, proventriculus, gizzard, pancrass, small and large intestine as well as liver. Villi height was decreased significantly ($P<0.01$) with increasing wheat screening level. Histological observations on jejunum of birds fed wheat screening with no enzyme addition showed shortening, thickening and atrophy of the villi, all of which improved when enzyme was included in diet. The levels of triglyceride, cholestrol and low density lipoprotein (LDL), decreased by increasing the level of wheat screening and this reduction was significant for LDL ($P<0.01$). Addition of enzyme to diet of young broiler chicks increased the concentration of blood cholesterol, triglycerides and LDL and this increasing was significant for LDL ($P<0.01$).

Key words: Wheat screening · Enzyme cocktail · Young broiler chicks · Gut morphology · Performance

INTRODUCTION

High levels of production and efficient feed conversion are characteristic of the modern poultry industry. Improvements in the efficiency of production must rely on obtaining maximum nutrient utilization from feedstuffs, which would also enable the use of a wide range of ingredients currently considered inferior. Corn has been used consistently as a major ingredient for poultry rations because of its high energy content and low cost. However, as corn markets tighten and corn supplies go to non agricultural uses such as ethanol production, wheat and its by product such as wheat screening make an excellent replacement for corn in poultry feeds, but dietary modifications need to be made because of its anti-nutritive fraction of non starch polysaccharides [1]. Wheat screening is a by product of seed production factories which includes high percentage of wheat seed and low percentage of broken wheat, shall, small weed seeds, chaff, hulls and dust. Wheat screenings can be used to replace a substantial portion of cereal in the diet of poultry and, therefore, can reduce production costs for poultry producers [2].

Wheat contains relatively high levels of nonstarch polysaccharide as a structural carbohydrate in the aleurone and endosperm walls [3]. Cellulose is a small proportion of the grain cell wall; the majority of the carbohydrate fraction is derived from b-glucan and arabinoxylan [4]. After ingestion, arabinoxylans become soluble, resulting in increased digesta viscosity [5]. The viscous nature of intestinal digesta seems to be responsible for negative effects exhibited by wheat pentosans. [1].

Increasing intestinal viscosity, impairs nutrient availability, decreases metabolizable energy and , consequently, lowers performance of birds fed wheat-

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based diets [6]. Successful attempts have been made to alleviate those disadvantages by microbial endoxylanase supplementation [7].

Exogenous enzymes can improve feed conversion ratio, reduce pollution associated with poultry manure and increase the use of low cost ingredients. In recent years, research has led to a much improved understanding of the ways in which exogenous enzymes can improve the nutritional value of wheat in poultry diets. One of the most commonly used enzymes for wheat-based diets is xylanase, which mainly acts on the arabinoxylan fraction of the wheat [4], thereby releasing the nutrients encapsulated within the cell walls and making them more available to the endogenous enzymes [1]. This experiment was conducted to study the effect of replacement of corn with wheat screening level and enzyme supplementation of starter diets, on performance, blood metabolites, gastrointestinal parameters and gut morphology of young broiler chicks.

MATERIALS AND METHODS

Sampling: A grade-1wheat screening sample known as Gaskojen with high dispersion in khorasan province (Iran) was obtained from a seed production planet. The chemical composition and metabolisable energy value of this sample were measured in another study [8] and data were used in the present study to formulate the diets.

Animal and Management: A total of 500 male broiler chickens (Ross 308) obtained from a commercial hatchery, were purchased, weighted and randomly assigned to 10 dietary treatments with 5 replicates of 10 birds each. Pens of 1×1 m, covered with wood shavings on the floors. Feed and water were provided *ad libitum*. Birds were exposed to 24 h of light for the first 7 d, then to a light:darkness cycle of 23 h light:1 h darkness until 10 d of age. Room temperature was maintained at 31°C for the first 7 d and 28.5° for the 2nd week.

Experimental Design and Diets: A completely randomized design with a factorial arrangement of five wheat screening level (0, 6, 12, 18 and 24%) and two levels of enzyme (o and 500 ppm) was used. The enzyme cocktail was consisted of 1200 unit g^{-1} xylanase and 440 unit g^{-1} β-glucanase. Diets were formulated to be isoenergetic and isonitrogenous (Table 1), based on the recommended nutrients by the Ross 308, 2007 manual for broiler chicks. The composition of experimental diets is shown in table1.

Table 1: Composition of starter diets fed to young broiler chicks

	Wheat screening (% of diet)				
Ingredients %	0	6	12	18	24
Corn	59.73	54.81	49.88	44.95	40.03
SBM	34.78	33.65	32.53	31.41	30.29
WS	0.0	6.0	12	18	24
Veg oil	0.77	0.82	0.87	0.92	0.97
Limestone	1.26	1.27	1.28	1.28	1.29
DCP	1.81	1.8	1.78	1.78	1.78
NaCl	0.34	0.33	0.32	0.32	0.30
Meth 98	0.35	0.35	0.35	0.34	0.34
Hcl Lys	0.34	0.35	0.36	0.37	0.37
Thronine	0.12	0.12	0.13	0.13	0.13
Vit-Min*	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Calculated values					
AME (Kcal/Kg)	2874	2874	2874	2874	2874
CP (%)	21	21	21	21	21
Ca (%)	0.99	1.00	1.00	1.00	1.00
AP (%)	0.48	0.5	0.5	0.5	0.5
Arg (%)	1.35	1.4	1.4	1.4	1.4
Lys (%)	1.36	1.4	1.4	1.4	1.4
Met+Cis(%)	1.1	1	1	1	1
Thr	0.89	0.9	0.9	0.9	0.9

*Supplied per kilogram of diet: vitamin A, 11000 IU; vitamin D3, 1800 IU; vitamin E, 36 mg; vitamin K3, 5 mg; vitamin B12, 1.6 mg; thiamine, 1.53 mg; riboflavin, 7.5 mg; niacin, 30 mg; pyridoxine, 1.53 mg; pantothenic acid, 12.24 mg; folic acid, 1 mg; and biotin, 0.03 mg; cholin chloride, 1100 mg; etoxycoin, 0.125 mg; iron, 250 mg; zinc, 84 mg; manganese,
160 mg; copper, 20 mg; iodine, 1.6 mg; and selenium, 0.2 mg.

Measurements: Broilers were weighed on a pen basis at 0 and 10 d of age and feed intake (FI) was determined and adjusted for mortality. Average daily gain (ADG) and feed conversion ratio (FCR), were also calculated. One broiler per pen was randomly selected, weighed and slaughtered at 10d of age and immediately afterward the small intestine was removed. Then the total segment of small and large intestine were emptied and weighed. The liver, proventriculus and gizzard were emptied and weighted. The weight of carcass parts and digestive tract organs were taken and expressed as a percent of body weight. After clearing intestinal content the middle portion of intestine between bile duct entry and Meckel's diverticulum was excised for histological study. The intestinal samples were fixed in 10% buffered formalin for 72 h and then rinsed for 30 min with running tap water. The samples were then immersed for 1 h in 30% then in 50% ethanol. All samples were stored in 70% ethanol until further histological processing. The tissues were embedded in paraffin wax using a Fisher 166 MP Histomatic Tissue Processor (Fisher Scientific, Pittsburgh, PA). Serial sections (5 ìm) were obtained using an AO-820 rotary microtome (American Optical Corporation, Buffalo, NY). The sections were placed on glass slides and stained with hematoxylin and eosin. Random intestinal villi (3 villi per field) were measured from the base of the intestinal mucosa to the tip of the villus using Meta Morph v.7.0 software (Molecular Devices, Downingtown, PA). Blood samples were taken from wing vein and serum samples were used to determine trigelyceride (TG), cholesterol (Chol), high density lipoprotein (HDL) and low density lipoprotein (LDL), using Selectra E auto analysis.

Statistical Analysis: All data were analyzed by ANOVA using GLM procedure of SAS (SAS Institute, 1999). Analysis of variance was performed using a randomized complete design with a factorial arrangement of treatments. All percentages data were transferred to arc-sin before statistical analysis. Data were statistically tested for main effects of wheat screening levels and enzyme supplementation and their interaction terms. Means were compared for significant differences using tukey multiple range test (P<0.05).

RESULTS AND DISCUSSION

Performance: Data for body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) of chicks fed with different levels of wheat screening with or without enzyme are shown in table 2. There was no significant difference in FI of birds fed with different levels of wheat screening during starting period (0-10 d).

Table 2: Effect of wheat screening level and enzyme addition on feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) of 10 day old broilers

Effects	FI	BWG	FC
Wheat screening (% of diet)			
0	21.53	16.24^{a}	1.33^{b}
6	21.31	15.94^{ab}	1.37^{ab}
12	21.74	15.97^{ab}	1.38^{ab}
18	21.69	15.03^{ab}	1.47^{ab}
24	22.01	13.81^{b}	1.59^{a}
SE	0.59	0.56	0.07
Enzyme			
-	21.51	14.69^{b}	1.49^{a}
+	21.80	16.10^{a}	1.37^{b}
SE	0.71	0.39	0.06
Level × Enzyme			
0 %-	21.30	15.78	1.35
+	22.76	16.70	1.31
6 %-	21.09	15.19	1.44
+	21.53	16.69	1.31
12 %-	21.78	15.64	1.42
+	21.71	16.31	1.34
18 %-	21.44	13.60	1.59
+	21.94	16.46	1.36
24 %-	21.95	13.28	1.65
+	22.07	14.34	1.54
SE	0.84	0.79	0.09

Means within a colomn with no common letter differ significantly (P < 0.05).
The supplemented enzyme contained 1200 unit g^{-1} xylanase and 440 unit g^{-1} β-glucanase

Table 3: Effect of wheat screening level and enzyme addition on relative weight of different section of gastrointestinal tract at 10 day of age

Effects	Liver (%)	Gizzard (%)	Proventriculus (%)	Pancreas (%)	Small intestine (%)	Large intestine (%)
Wheat screening (% of diet)						
0	3.66	4.10	0.98	0.53	6.93	1.24
6	3.91	4.39	1.03	0.59	6.97	1.34
12	3.95	4.44	0.96	0.61	7.22	1.29
18	4.08	4.43	0.97	0.61	7.36	1.29
24	4.02	4.60	0.99	0.62	7.37	1.35
SE	0.23	0.20	0.05	0.04	0.44	0.10
Enzyme						
-	4.31[a]	4.78[a]	1.07[a]	0.70[a]	7.62[a]	1.44[a]
+	3.54[b]	4.01[b]	0.91[b]	0.48[b]	6.72[b]	1.17[b]
SE	0.15	0.13	0.03	0.03	0.28	0.06
Level × Enzyme						
0-	3.84	4.37	1.02	0.63	7.29	1.38
+	3.48	3.83	0.95	0.43	6.58	1.10
6-	4.09	4.47	1.06	0.66	7.48	1.40
+	3.73	4.30	0.99	0.52	6.45	1.28
12-	4.18	4.54	1.06	0.68	7.58	1.30
+	3.73	4.34	0.86	0.54	6.85	1.29
18-	4.77	4.88	0.99	0.75	7.75	1.50
+	3.39	4.00	0.95	0.48	6.98	1.08
24-	4.66	4.62	1.21	0.81	7.99	1.59
+	3.37	3.58	0.77	0.42	6.75	1.12
SE	0.33	0.28	0.08	0.06	0.62	0.14

Means within a colomn with no common letter differ significantly ($P < 0.05$).
The supplemented enzyme contained 1200 unit g^{-1} xylanase and 440 unit g^{-1} β-glucanase

Saki and Alipana [9] reported that there was no significant difference in feed intake of broiler chicken fed diet by different levels of wheat screening.

The BWG, decreased and FCR, increased significantly ($P<0.05$) with increasing wheat screening level. Birds fed with 6, 12 and 18% wheat screening diets had almost the same BWG, but those fed diet with 24% wheat screening significantly had lower BWG compared to control ones.

Proudfoot and Hulan [10] found no significant effect on growth and feed efficiency of broiler chickens fed with 64 different wheat screening samples collected over a three years period and represented up to 45% of the diet. Stapleton *et al.* [11] studied five different commercial samples of wheat screenings in feeding studies with broiler chickens to 4 wk of age. No significant effect of wheat screenings was observed on body weight and feed conversion ratio.

Enzyme supplementation significantly ($P<0.01$) increased BWG and decreased FCR ($P<0.05$). Our results are in agreement with Manwar and Mandal [12], who reported that the addition of enzymes significantly improved feed conversion ratio (FCR) over the raw wheat-based diets. Steenfeldt *et al* [13], showed significant improvement in BWG and FCR with addition of enzyme. McCracken and Quintin [14] reported that enzyme addition improved live weight gain and gain: feed ratio. It has been reported that the enzymes improve the utilisation of nutrients and feed efficiency by degrading the viscous polysaccharides presented in wheat [15].

Gastrointestinal Parameters: The average relative weight of different section of gastrointestinal tract of broilers fed with different level of wheat screening with or without enzyme addition is shown in Table 3. The gastrointestinal tract weight was not affected by different levels of wheat screening in diet. The larger gizzards observed in chicks fed with wheat screening as compared with those fed the corn-soybean diet were in accordance with results reported earlier with whole grains [16]. This result is a consequence of the increased grinding activity of the gizzard. The increase in small intestine weight for birds fed diets contained wheat screening may be related to an increase in the function of this part, due to an increase in non starch polysaccharide (NSP) and digesta viscosity which led to a feedback mechanism in gut motility and therefore size of this organ. Petterson and Aman [17] observed that the small intestine of birds fed a wheat-based diet was 3% longer than those fed the same diets supplemented with an endoxylanase. Other authors have also observed that dietary fiber ingestion leads to increased size and length of the digestive organs in pigs [18], chickens [19] and rats [20].

Table 4: Effect of wheat screening level and enzyme addition on gut morphology of broilers at 10 day of age

Effects	Villi Height (µm)	Villi weidth(µm)	Crypt Depth (µm)
Wheat screening (% of diet)			
0	369.03[a]	59.78	111.69
12	352.76[a]	62.77	109.23
24	321.84[b]	66.28	108.64
SE	5.62	2.96	4.58
Enzyme			
-	327.34[b]	64.24	105.84
+	368.41[a]	61.65	113.87
SE	4.59	2.42	3.74
Level × Enzyme			
0-	343.45	58.54	114.92
+	394.61	61.02	108.47
12-	322.81	64.45	103.54
+	382.70	61.08	114.92
24-	315.75	69.72	99.05
+	327.93	62.85	118.23
SE	7.95	4.19	6.48

Means within a colomn with no common letter differ significantly ($P < 0.01$).

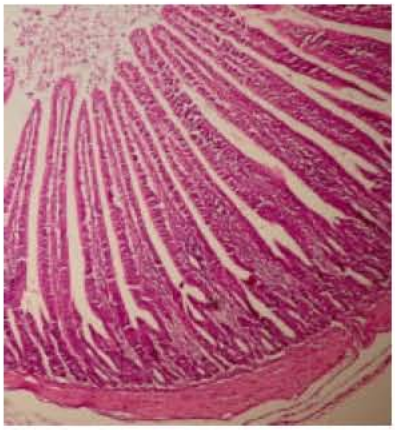
The supplemented enzyme contained 1200 unit g^{-1} xylanase and 440 unit g^{-1} β-glucanase

Enzyme supplementation significantly (P<0.05) decreased weight of gastro intestinal tract including proventriculus, gizzard, pancrass, small and large intestine, as well as liver of birds fed diets contained wheat screening. It has been reported that enzyme supplementation, eliminate negative effects of non starch polysaccharides such as enlargement of gastrointestinal tract in broiler chickens [21] and laying hens [22]. No information about specific physiological mechanisms exists in the literature that explains reducing intestinal size in response to dietary enzyme supplementation. However, it is generally accepted that the viscous properties of water-soluble NSP are mainly responsible for the anti-nutritive effects in poultry [23]. It was speculated that the significant reduction in the intestinal size of birds fed wheat-based diets supplemented with pentosanase might be a consequence of the breakdown of polysaccharides into smaller polymers [24], thereby reducing their viscosity.

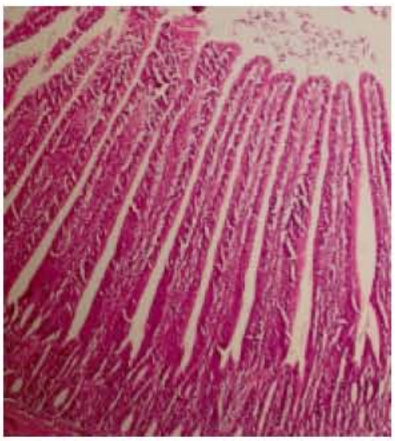
Histological Observation: Gut morphology properties of jujenum of young broiler chicks fed diet with different levels of wheat screening and enzyme are shown in table 4. Increasing level of wheat screening, increased villi width and decreased crypt depth but these changes were not significant. Although villi height decreased significantly (P<0.01) with increasing wheat screening level. Enzyme supplementation significantly (P<0.01) increased villi height. Histological observations on jejunum of birds fed wheat screening without enzyme showed shortening, thickening and atrophy of the villi (Figure 1), all of which improved when enzyme was included in the diet. This result is similar to result reported by Jaroni *et al.* [1]. They showed shorter and thicker villi in birds fed with 8 and 16 % wheat middling. Non starch polysaccharides in wheat based diets caused to increase viscosity of intestine digesta which stimulate anaerobic microflora growth. Microorganisms migrate to small intestine where most nutrient absorption takes place [25], high bacterial concentration can irritate the gut lining and caused to thickening and atrophy of villis [26]. Enzyme supplementation can reduce microbial population [27] and atrophy of villis [22].

Blood Parameters: The serum triglyceride (TG), cholesterol (CH), low density lipoprotein (LDL) and high density lipoprotein of chicks fed diet with different level of wheat screening with or without enzyme supplementation are shown in table 5. The levels of TG, CH and LDL, decreased by increasing level of wheat screening and the difference was only significant for LDL (P<0.01).

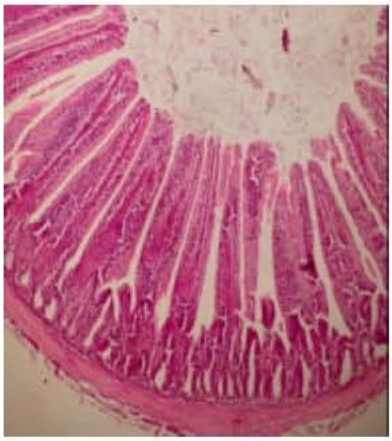
A negative correlation exists between dietary fiber content and serum cholesterol level [28]. Moundras *et al.* [29] reported that the plasma cholesterol lowering effect of crude fiber may be due to its ability to enhance fecal



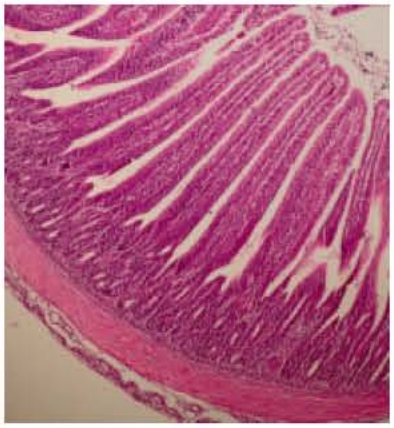
part of a section of jejunum of a bird fed control diet



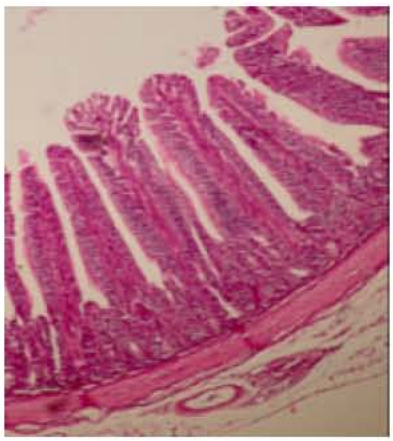
part of a section of jejunum of a bird fed control diet plus enzyme



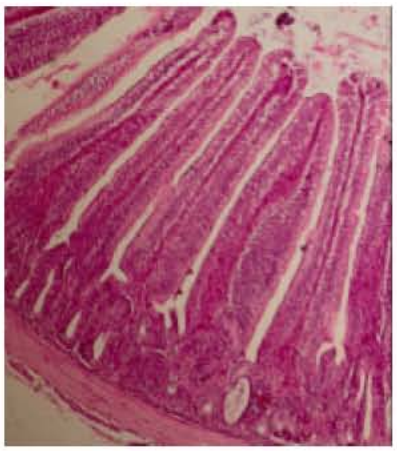
part of a section of jejunum of a bird fed 12% wheat screening



part of a section of jejunum of a bird fed 12% wheat screening plus enzyme



part of a section of jejunum of a bird fed 24% wheat screening



part of a section of jejunum of a bird fed 24% wheat screening plus enzyme

Fig. 1: Effect wheat screening level and enzyme supplementation on gut morphology of 10 days old broiler chicks

Table 5: Effect of wheat screening level and enzyme addition on serum lipids of broilers at 10 day of age

Effects	TG (mg/dl)	CH (mg/dl)	HDL (mg/dl)	LDL (mg/dl)
Wheat screening (% of diet)				
0	130.60	126.20	75.28	24.80^{a}
6	118.20	123.50	77.56	22.30^{ab}
12	115.30	121.70	78.04	20.60^{b}
18	114.60	121.20	79.28	19.00^{b}
24	113.40	117.80	76.52	18.60^{b}
SE	4.44	4.55	4.35	0.99
Enzyme				
-	115.24	120.48	77.43	20.00^{b}
+	121.60	123.68	77.24	22.12^{a}
SE	2.81	2.88	2.75	0.63
Level × Enzyme				
0-	126.40	123.60	74.52	23.80
+	134.80	128.80	76.04	25.80
6-	115.80	121.60	77.44	21.00
+	120.60	125.40	76.68	23.60
12-	112.60	121.00	79.08	19.40
+	118.00	122.40	77.00	21.80
18-	108.40	119.60	79.92	18.00
+	120.80	122.80	78.64	20.00
24-	113.00	116.60	76.20	17.80
+	113.80	119.00	76.84	19.40
SE	6.29	6.44	6.16	1.40

Means within a colomn with no common letter differ significantly ($P < 0.01$).

The supplemented enzyme contained 1200 unit g^{-1} xylanase and 440 unit g^{-1} β-glucanase

excretion of cholesterol and bile acids. Daggy *et al.* [30] reported that the fiber induces both enhanced liver excretion and diversion of intestinal steroids to the feces. Durdi and Gharejeh [31] reported that reduction in total cholesterol concentration and increased HDL to total cholesterol ratio is probably caused by enhanced reverse cholesterol transport in response to intestinal loss of dietary fat. Mathlouthi *et al.* [32] reported that indigestible polysaccharides can act directly by increasing bile acid excretion. Adrizal and Ohtani [33] confirmed that non-starch polysaccharides have binding property with bile acids. This led to increasing fecal and reducing serum cholesterol. Reduction in cholesterol parameter is parallel to increase in HDL and reduce LDL and VLDL in serum [34].

The present study showed that adding enzyme to young broiler chicks diet increased the concentration of blood cholesterol, triglycerides and LDL and this increasing was significant for LDL (P<0.01). Studies with animal models have shown that high level of dietary cholesterol saturated fatty acids and an increased small intestinal uptake of these components due to enzyme supplementation of the diet may increase plasma cholesterol levels [28]. Supplementation of enzyme may alleviate the limitations present for the function of bile salts and the emulsifying properties of them in intestinal chyme and therefore it might be a reason for increasing total fat in blood [35]. It is reported that the digestion of big molecules of carbohydrates with pentosanase (arabinoxylanase) can change the viscous nature of intestinal chyme and therefore improves fat digestibility [36].

CONCLUSION

In conclusion, the result of this study showed the beneficial use of 18 % wheat screening as a by-product with low price in starter diets without any adverse effect on young broiler chick's performance. However, increasing level of wheat screening, caused to increase in feed conversion ratio, enlargement of gastrointestinal tract, increasing LDL level of serum, shortening, thickening and atrophy of the villi, all of which improved when enzyme was included in the diet.

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