

Effect of Dietary Replacement of Soyabean Meal with Toasted Sesame Seed on Performance, Tibia Bone Mineralisation and Gut Morphology of Broiler Chicken

ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

The abstract should be concise and informative. It should not exceed 300 words in length. It

Aims: This experiment was conducted to assess the effect of dietary replacement of soybean meal with toasted Sesame seed on performance, tibia bone mineralization and gut morphology of broiler chicken.

Study design: The design of the study was a completely randomized design. **Place and Duration of Study:** The experiment lasted for 8weeks.

Methodology: A total of 150 one-day old broiler birds were randomly allotted into 5 experimental treatments with 3 replicates each (10 birds per replicate) in a completely randomized design. Toasted sesame seed supplemented with 600ppm microbial phytase was replaced in the dietary treatments at 0%, 10%, 20%, 30% and 40% for Soyabean meal both at the starter and finisher phase and the experiment lasted for 8weeks.

Feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) were measured and calculated weekly throughout the experiment. Six birds per treatment were selected at the end of the experiment, the birds were then slaughtered by cervical dislocation and the two tibia bones were removed and cleaned of all adhering muscle and cartilaginous caps for tibia bone mineralization, section of ileum and jejunum tissues were also collected for gut morphological parameters. All data obtained were analyzed with one way ANOVA using SAS 1990 software at 5% probability level while means were compared using Duncan Multiple Range Test.

Results: There were significant ($P<0.05$) differences in the performance characteristics across the treatments with birds fed 10% TSS having the highest weight gain of 54.36g/bird/day compared to the control of 38.71g/bird/day (0%TSS). The FCR in birds fed 10% TSS (1.62) and 20% TSS (1.72) revealed a better feed utilisation compared to birds fed diet 5 which recorded the highest FCR value of 3.72. The concentration of Ca, Mg, Zn, Fe and PO_4 in the tibia were significantly ($P<0.05$) different across the treatments. The villus height was highest in treatment 4 (5930.2 μ m) and the least in the control (2456.5 μ m) in the ileum but in the jejunum, the control was the highest (4292.6 μ m) and least in treatment 2 (2859.5 μ m). Crypt depth were significantly ($P<0.05$) different across the treatments in both the ileum (1736.36 – 836.34 μ m) and jejunum (1269 – 605.5 μ m).

Conclusion: It can therefore be concluded that replacement of Soybean meal with toasted Sesame seed up to 20% inclusion level in broiler ration results in better performance and improved health condition of broiler birds.

Keywords: Soybean, Toasted Sesame seed, Replacement levels, Tibia mineralization and Gut morphology

1. INTRODUCTION

Animal research in Nigeria has displayed interest and promoted virtually all species and products. However, in terms of improvement, interest has been shown towards

environmental management in the area of nutrition. Nutrition is an important component of the environment under all climatic conditions. If nutrition falls below standard, birds may not be able to fully express their genetic potentials and it has been considered that environmental factors affect a proportion of 85% birds performance [1]. The possible threats from pathogenic bacteria and greater variability in protein quality in animal protein sources encourage the use of higher levels of vegetable protein sources in poultry diets. However they are deficient in one or more of the essential amino acids, therefore to achieve a balanced amino acids intake, a variety of plant protein sources need to be complemented with each other in the diet. Legumes containing anti-nutritional factors in seeds are a major factor limiting the exploitation of alternative grain legumes as protein source for poultry [2]. Anti-nutritional factors have negative effects on digestion and performance of fowls [3].

Soybean meal has long been considered the best source of supplemental protein in diets for poultry. In fact, it is often referred to as the "gold standard" among intact protein sources used in the animal feed industry [4]. However, soybean meal is becoming extremely expensive in the last decade especially in developing countries, and also the non availability of this soybean meal (SBM) at an economically viable price, make the use of alternative protein source in poultry diets necessary. Therefore, search for alternative vegetable protein sources, which are cheap and locally available, has become an urgent subject to poultry nutritionists [5] and one of these available alternate protein source is Sesame (*Sesamum indicum*).

Sesame also known as benniseed is one of the ancient oil seed crops used by man and when used in the right proportions together with soybean meal which has a higher content of lysine; a balanced diet with respect to lysine and methionine will result [6]. Sesame seeds are also good source of manganese, copper, calcium, magnesium, iron, phosphorus, vitamin B1, zinc and other substances which limit their use in monogastric animal feed. Incidentally, both plants (Soyabean and Sesame) are high in phytic phosphorus which reduces phosphorus and calcium availability however, this adverse effect could possibly be overcome by dietary supplementation with exogenous phytase [7]. It has been demonstrated that the supplementation of poultry diets with exogenous phytases improves mineral retention, bone strength, feed conversion ratio (FCR), amino acid digestibility coefficients and other performance parameters [8].

Appropriate nutritional levels promote the normal development of bone tissue [9]; therefore, nutritional deficiencies can cause bone structure alterations. Calcium (Ca) is the most abundant mineral in the body of animals [10]. Well over 90% of Ca is found in the bones where it combines with Phosphorus, the second most abundant mineral in bone.

Differentiation of the epithelial cells along the length of the gut continues to be a source of interesting information about the development and function of the digestive system. The epithelium varies from a squamous lining in the esophagus and crop to the highly specialized acid-secreting cells of the proventriculus. In the small intestine, the epithelium is thrown into long folds, the villi, which serve to increase the surface area for enzyme secretion and nutrient absorption. It is well documented that the structure and morphology of villi play a substantial role in the digestion and absorption of nutrients in the gastrointestinal tract [11]. Nutrient absorption in the gastrointestinal tract is more effective with increase in the size and height of intestinal villi [12]. Factors such as diet and genetics [13] were found to influence the morphology of the intestinal villi.

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70 2. MATERIAL AND METHODS

71 A total of 150 one day-old broiler birds were used for the experiment. The birds were then
72 divided into 5 dietary treatments, consisting of 3 replicates with 10 birds per replicate in a
73 completely randomized design. The management of the birds was carried out according to
74 the procedure of Oluyemi and Robert [14].

75

76 Experimental Diets

- 77 • Diet 1 =Diet contained 40% Soybean meal without toasted Sesame seed and
78 Pyhtase (Control)
- 79 • Diet 2 = Diet contained 30% Soybean meal with 10% toasted Sesame seed and
80 Phytase (600ppm)
- 81 • Diet 3 = Diet contained 20% Soybean meal with 20% toasted Sesame seed and
82 Phytase (600ppm)
- 83 • Diet 4 = Diet contained 10% Soybean meal with 30% toasted Sesame seed and
84 Phytase (600ppm)
- 85 • Diet 5 = Diet contained no Soybean meal with 40% toasted Sesame seed and
86 Phytase (600ppm)

87 The sesame seeds were purchased from a local market and were toasted until a golden
88 brown colour is achieved. It was then removed immediately from the heat source to prevent
89 burning.

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93 **Table 1. Gross Composition of the Starter Diet**

Ingredient (%)	DIET 1	DIET 2	DIET 3	DIET 4	DIET 5
Maize	52.40	52.30	52.20	52.00	51.90
SBM	40.00	30.00	20.00	10.00	0.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Toasted SS	0.00	10.00	20.00	30.00	40.00
Palm oil	2.90	2.90	2.90	2.90	2.90
Lysine	0.10	0.15	0.25	0.45	0.55
Limestone	1.00	1.00	1.00	1.00	1.00
DCP	1.00	1.00	1.00	1.00	1.00
Methionine	0.15	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25	0.25

Vitamin premix	0.25	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100	100
Crude protein %	22.80	22.85	22.80	22.79	22.79
ME kcal/kg	3020	3016	3009	3000	2995
Calcium%	1.00	1.10	1.13	1.12	1.20
Total phosphorus%	0.53	0.54	0.56	0.56	0.60

94 SBM: Soybean Meal, DCP: Di-Calcium Phosphate, Toasted SS: Toasted Sesame Seed,
95 ME: Metabolizable Energy
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Table 2. Gross Composition of the Finisher Diet

Ingredient (%)	DIET 1	DIET 2	DIET 3	DIET 4	DIET 5
Maize	50.20	50.20	50.20	50.20	50.20
SBM	40.00	30.00	20.00	10.00	0.00
Toasted SS	0.00	10.00	20.00	30.00	40.00
Palm oil	1.00	1.00	1.00	1.00	1.00
Wheat bran	5.00	5.00	5.00	5.00	5.00
Lysine	0.15	0.15	0.15	0.15	0.15
Limestone	1.50	1.50	1.50	1.50	1.50
DCP	1.50	1.50	1.50	1.50	1.50
Methionine	0.15	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25

TOTAL	100	100	100	100	100
Crude protein (%)	22.02	22.03	22.04	22.05	22.06
ME (kcal/kg)	2855	2853	2851	2849	2847
Calcium(%)	1.05	1.20	1.23	1.25	1.30
Total phosphorus(%)	0.50	0.60	0.61	0.62	0.65

104 SBM: Soybean Meal, DCP: Di-Calcium Phosphate, Toasted SS: Toasted Sesame Seed,
105 ME: Metabolizable energy

107 2.1 DATA COLLECTION

109 2.1.1 Performance Parameters

110 The weekly feed intake and weight gain were recorded. Feed conversion ratio was
111 calculated during the 8 weeks experimental period.

113 2.1.2 Histo-Morphology of the Small Intestine

114 Samples (section of ileum and jejunum tissues) were collected from two birds per replicate
115 (a total of 6 birds per treatment). All birds were randomly selected, weighed and then
116 slaughtered by cervical dislocation. The contents of the Jejunum and Ileum were carefully
117 hand-stripped. Segments measuring 2 cm in length from the mid-points of jejunum and
118 ileum were excised, washed in physiological saline solution, and fixed in 10% buffered
119 formalin. The tissue samples were later embedded in paraffin, and a 2 mm section of each
120 sample was placed on a glass slide and stained with haematoxylin and eosin. Histological
121 sections were examined with a phase contrast microscope coupled with an integrated digital
122 imaging analysis system (Biowizard 4_2, Dewinter Optical Inc., Delhi, India). The variables
123 measured were villus height, crypt depth and thickness of the muscularis mucosae. Villus
124 height was measured from the top of the villus to the top of the lamina propria, and the crypt
125 depth was measured from the base up to the region of transition between the crypt and
126 villus. Altogether 10 measurements were taken per bird for each variable; for purposes of
127 statistical analysis, the average of these values was used [15].

129 2.1.3 Bone Mineralisation

130 Two chicks from each of the 15 replicates were selected and slaughtered by cervical
131 dislocation and their tibia were removed and cleaned of all adhering muscle and
132 cartilaginous caps after which they were de-fatted by soxhlet extraction using petroleum
133 ether. Fat-free dry tibias were ashed at 600±30°C for 12hour. The fat-free tibias were ground
134 and approximately 200 mg taken for analysis. The amount of calcium, Phosphorus,
135 Magnesium and Zinc in the tibia ash were determined spectrophotometrically using the
136 standard curve according to AOAC [16].

138 2.1.4 Statistical Analysis

139 All data obtained were subjected to statistical analysis of variance (ANOVA) using SAS [17]
140 software at 5% probability level and significant treatment means were separated using
141 Duncan's multiple Range test.

143 3. RESULTS AND DISCUSSION

145 **Table 3: Performance Characteristics of Birds Fed Dietary Replacement of Soybean**
146 **Meal with Toasted Sesame Seed Supplemented with Phytase**

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Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM
Initial weight (g/bird)	140.00	136.67	123.33	126.67	136.67	5.37
Final weight (g/bird)	2036.67 ^c	2800.00 ^a	2556.67 ^b	1573.33 ^d	870.00 ^c	64.24
Weight gain (g/bird/day)	38.71 ^c	54.36 ^a	49.66 ^b	29.52 ^d	14.97 ^c	1.34
Feed intake (g/bird/day)	86.80 ^a	88.03 ^a	85.50 ^a	73.95 ^b	55.51 ^c	2.54
FCR	2.25 ^b	1.62 ^c	1.72 ^c	2.51 ^b	3.72 ^a	0.09

^{abcd} Means along the row with the same superscript are not significantly (P>0.05) different

SEM = Standard Error of Means FCR = Feed Conversion Ratio. Diet 1 =Diet contained 40% Soybean meal without toasted Sesame seed and Pyhtase (Control) , Diet 2 = Diet contained 30% Soybean meal with 10% toasted Sesame seed and Phytase (600ppm), Diet 3 = Diet contained 20% Soybean meal with 20% toasted Sesame seed and Phytase (600ppm), Diet 4 = Diet contained 10% Soybean meal with 30% toasted Sesame seed and Phytase (600ppm), Diet 5 = Diet contained no Soybean meal with 40% toasted Sesame seed and Phytase (600ppm)

The result from Table 3 on the performance characteristics revealed no significant (P>0.05) differences in the initial weight. The final weight were significantly different (P<0.05) across the treatments with birds on 10% toasted Sesame seed (TSS) having the highest final body weight of 2800 g/bird and their counterpart on 40% SS having the least weight of 870 g/bird. The result of weight gain also showed significant (P<0.05) differences across the treatments with birds on 10% TSS having the highest weight gain of 54.36g/bird/day and birds on 40%TSS having the least of 14.97g/bird/day. However, no significant (P>0.05) differences were observed in the feed intake of birds fed Control (without toasted Sesame inclusion), 10%TSS and 20%TSS diets with mean values of 86.80, 88.03 and 85.5 g/bird/day respectively. The result also revealed significant (P<0.05) differences in the feed conversion ratio of the birds across the treatments with birds on 40% TSS having the highest value of 3.72 with birds on 10%TSS and 20%TSS having least significant values of 1.62 and 1.72 respectively.

Table 4. Tibia Bone Mineralization of Birds Fed Dietary Replacement of Soybean Meal with Toasted Sesame Seed supplemented with phytase

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM
Ca(mg/100g)	484.33 ^b	552.75 ^a	531.75 ^a	478.75 ^b	464.25 ^b	13.28
Fe(mg/100g)	8.42 ^a	7.10 ^b	7.10 ^b	7.01 ^b	6.95 ^b	0.16
Zn(mg/100g)	1.98 ^a	1.73 ^{ab}	1.62 ^{ab}	1.52 ^b	1.33 ^b	0.14
Mg(mg/100g)	18.05 ^b	26.83 ^a	26.65 ^a	22.95 ^{ab}	21.48 ^{ab}	1.74
PO ₄ (mg/100g)	323.50 ^{ab}	375.00 ^a	329.75 ^{ab}	260.63 ^b	252.75 ^b	25.85

^{abcd} Means along the row with the same superscript are not significantly (P>0.05) different

SEM = Standard Error of Means FCR = Feed Conversion Ratio. Diet 1 =Diet contained 40% Soybean meal without toasted Sesame seed and Pyhtase (Control) , Diet 2 = Diet contained 30% Soybean meal with 10% toasted Sesame seed and Phytase (600ppm), Diet 3 = Diet contained 20% Soybean meal with 20% toasted Sesame seed and Phytase (600ppm), Diet 4 = Diet contained 10% Soybean meal with 30% toasted Sesame seed and Phytase (600ppm), Diet 5 = Diet contained no Soybean meal with 40% toasted Sesame seed and Phytase (600ppm)

Ca: Calcium Fe: Iron Zn: Zinc Mg: Magnesium PO₄: Phosphate

The result of tibia bone mineralisation of birds fed dietary replacement of Soybean meal with toasted Sesame seed as observed in table 4 showed that the Calcium (Ca) level in the tibia of the experimental birds differed ($P<0.05$) significantly across the treatments with bone from birds on 20%TSS having the highest mean value of 552.75mg/100g and the least in birds fed 40%TSS (464.25 mg/100g). The Iron and Zinc values obtained as shown in the table showed there were significant differences ($P<0.05$) in birds fed the control diet and the others. For Magnesium, the highest value was obtained in birds fed 10%TSS (26.83 mg/100 g) and the lowest mean value (18.05 mg/100g) was obtained in birds fed the control diet. The highest value (375.00 mg/100g) was obtained in birds fed 10%TSS for Phosphate while the lowest mean value (252.75 mg/100g) was obtained in birds fed 40%TSS. Generally, there was a decrease in the values across the treatment as the inclusion of TSS increases.

Table 5: Histological Parameters of Birds Fed Dietary Replacement of Soybean Meal With

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM
Ileum (μm)	2456.5 ^c	3383.2 ^b	5561.1 ^a	5930.2 ^a	3264.3 ^b	207.14
Villus height						
Crypt depth	1108.17 ^c	1258.28 ^{bc}	1333.43 ^b	1736.36 ^a	836.34 ^d	50.22
SMW	1675.3 ^c	4763.4 ^a	2779.8 ^b	1986.3 ^c	1580.9 ^c	116.77
Jejunum (μm)						
Villus height	4292.6 ^a	2859.5 ^b	3944.8 ^a	4075.1 ^a	3227.7 ^b	220.48
Crypt depth	798.6 ^b	1147.5 ^a	1264.9 ^a	1269.4 ^a	605.5 ^b	77.92
SMW	1711.3 ^{cd}	4600.7 ^a	3122.9 ^b	2662.2 ^{bc}	1461.0 ^c	301.66

^{abcd}: Means along the row with the same superscript are not significantly different ($P>0.05$)

SEM: Standard error of mean SMW: Smooth muscular wall. Diet 1 =Diet contained 40% Soybean meal without toasted Sesame seed and Phytase (Control) , Diet 2 = Diet contained 30% Soybean meal with 10% toasted Sesame seed and Phytase (600ppm), Diet 3 = Diet contained 20% Soybean meal with 20% toasted Sesame seed and Phytase (600ppm), Diet 4 = Diet contained 10% Soybean meal with 30% toasted Sesame seed and Phytase (600ppm), Diet 5 = Diet contained no Soybean meal with 40% toasted Sesame seed and Phytase (600ppm)

The result as shown in table 5 indicated a significant ($P<0.05$) difference for ileum in the values recorded for villus height of birds fed the experimental diets, birds fed diets 3 and 4 that were replaced with 20% and 30% TSS were significantly higher (5561.1 and 5930.2 μm) respectively than others. Although birds fed diet 2 and 5 were not significantly ($P>0.05$) different from one another, they were significantly higher than the control. The trend observed for the crypt depth of the ileum showed a significant ($P<0.05$) difference with the highest value in birds fed diet 4(1736.36 μm). Birds on diet 3(1333.43 μm) were numerically higher but not significantly different from those on diet 2(1258.28 μm) and birds on diet 5(836.34 μm) had the least mean value. The smooth muscular width of ileum in this measurement showed highest mean value in birds fed diet 2(4763.4 μm).

Data obtained for jejunum revealed significant differences ($P < 0.05$) in all the parameters measured. The values recorded for villus height in birds fed diets 3 (3944.8 μm) and 4 (4075.1 μm) were not significantly ($P > 0.05$) different from the control (4292.6 μm), however, significantly ($P < 0.05$) lower value was recorded for birds on diets 2 and 5. Crypt depth showed significantly higher ($P < 0.05$) values in birds fed diets 2, 3 and 4 while the

value recorded for those on diet 5 (605.5 μ m) was not significantly different from the control (798.6 μ m). Result recorded for the smooth muscular width in the jejunum also showed highest mean value in birds fed diet 2(4600.7 μ m) and least mean value in those diet 5(1461.0 μ m), though not significantly ($P > 0.05$) different from birds on diet 4 and the control.

230

231 **4. DISCUSSION**

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233 The highest values obtained for body weight gain in diets 2 and 3, (10%TSS and 20%TSS
234 respectively) suggests the possible influence of effective substitution of soybean meal with
235 toasted Sesame Seed on the weight gain. It was reported in two separate studies that
236 Sesame may provide an acceptable alternative to soybean meal in broiler rations when
237 substituted at level 15% or less [18] [19], broilers performance was depressed by feeding a
238 diet containing 30% Sesame seed meal (SSM) or more [20] [21] which was observed in this
239 study. This claim can also be attributed to the use of phytase enzyme used in this study
240 because several authors had reported that supplementation of exogenous phytase is
241 effective for optimum growth in poultry.

242 The values recorded for feed intake may suggest a possible influence of the presence of
243 some anti-nutritional factor in Sesame seed. This is an agreement to the reports by Al-Harthi
244 and El-Edeek [22] that birds consumes less of feed containing high amount of Sesame.
245 Although the seed was toasted to reduce the anti-nutritional factor in it, Abeke and Otu [23]
246 reported that heat treatment can only reduce the effect of anti-nutritional factors not totally
247 remove it. Odunsi and Longe [24] had also linked factors such as texture, taste and odour
248 with level of feed consumption.

249

250 Diet 2 and 3 containing 10% and 20% toasted Sesame seed inclusion had a better feed
251 utilization than the control (Diet 1) that had no inclusion of toasted Sesame seed, a lower
252 value of FCR is an indication of better performance and feed conversion into flesh. However
253 diet 5 with 40% inclusion of toasted Sesame seed had poor feed utilization and Kaneko *et al*
254 [21] had reported a depressed performance in broiler chicken when Sesame seed totally
255 replaced Soybean meal.

256

257 There was increase in the mineral retention of Calcium and Phosphate in the tibia of birds
258 fed the experimental diets 10%TSS and 20%TSS inclusion rates when compared with the
259 control and a decrease in value as inclusion of toasted Sesame seed increased in the diets.
260 This implies a reduction in the inhibitory effect of phytic acid on mineral absorption through
261 its hydrolysis by phytase as well as toasting of the seeds as the sesame seeds inclusion
262 increased. This agrees with the previous study of Sebastian *et al* [25] where increased
263 retention of phosphorus and calcium in bone were observed from the tibia of birds fed diets
264 supplemented with phytase. Also there was a decrease as the inclusion of TSS increases in
265 Fe, Zn and Mg and this is in agreement with the work of Zanini and Sazzad [26] who
266 reported an increase in the concentration of Fe and Zn in the tibia by phytase
267 supplementation. Removal or reduction of phytate in food generally improves zinc
268 bioavailability [27].

269 Most of the digestive and absorptive processes of ingested feeds occur in the intestine. It
270 has been reported that intestinal villus and epithelial cell morphology is associated with
271 intestine function and growth rate [28]. The increase in the villus height as the inclusion of
272 toasted Sesame seed (TSS) increases to 30% inclusion rate showed that TSS has the ability
273 of increasing the villus height and thus the intestinal surface area for absorption because
274 Caspary [29] confirms that Increase in the villus height suggests an increased surface area
275 capable of greater absorption of available nutrients also large-sized villi have been
276 associated with activated cell proliferation [30]. The crypt depth in this study showed
277 corresponding increase as the villus increases because long villi indicate a faster

multiplication of the base of the crypt which migrated faster to the tip of villi [31]. However, as the villus height and crypt depth increases with increase in inclusion rate of TSS to 30%, there was no corresponding increase in the growth rate and this showed that though there was increase in villus height, its functions were not well activated because greater villus height and numerous epithelia cells are indicators that the function of the intestinal villi is activated [32] [33] and this is because the mucularis which contain the epithelia cells when measured in this study became shorter as the villus height increases. This agrees with the findings of Nordstrom and Dahlqvist [31] who reported that long villi indicate a faster multiplication of the base of the crypt which migrated faster to the tip of villi and the turnover of the epithelial cells would therefore be shorter. Numerous epithelial cells will be observed in chickens with increased body weight [11]. The function of the epithelial layer is fundamental to the digestion and absorption of nutrients from the intestinal lumen. The epithelium is covered by a layer of mucus composed of mucin glycoproteins that are synthesised by goblet cells. The mucous layer acts as a layer of protection, lubrication and transport between luminal contents and epithelial cells [34]. Changes in the properties of this barrier could affect the absorption of both dietary and endogenous macromolecules and ions such as in nutrition, the same trend was observed in the ileum and jejunum in this study.

5. CONCLUSION

Based on the findings of this study, replacing Soybean with toasted Sesame seed above 20% has adverse effect on the performance and predisposed the birds to serious health hazards. It can therefore be concluded that replacement of Soybean meal with toasted Sesame seed up to 20% inclusion level in broiler ration results in better performance and improved health condition of broiler birds. In view of the findings of this study, it is recommended that toasted Sesame seed supplemented with phytase can replace Soybean meal up to 20% inclusion level.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

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