

Production Performance, Serum Biochemical, Intestine Morphology and Nutrient Digestibility of Broiler Feed Diet and High in Fiber Contain Different Levels of Pectinase

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Abstract

Investigation evaluated the effect of reducing energy, adding an enzyme, and oat-based nutritional systems on the performance of meat chickens. Seven diets were tested: T1 (control diet), T2 (control diet - 150 kilocalories), T3 (control diet - 300 kilocalories), T4 (T2 + 300 grams of pectinase), T5 (T3 + 300 grams of pectinase), T6 (30% oat-based diet - 150 kilocalories with 300gm of pectinase enzymes), and T7 (oat-based diet 30% - 300 kilocalories with 300gm of pectinase enzymes). The experiment was aimed to evaluate growth rate, nutrient digestion, intestinal structure, and serum biochemical. The results showed that the energy reduction in the T2 and T3 systems led to a decrease in performance compared to normal groups. However, addition of enzyme from T4 and T5 resulted in a marked increase in growth rate, feed conversion factor, and nutrient utilization compared to a low-energy based diet. Diets containing 30% oat (T6) showed the best overall results relating to feed efficiency, weight gain and actual body weight ($P < 0.05$). The addition of the pectinase enzyme from T7 diet also resulted in better development and intestinal structure compared to diets that do not contain oat-based supplements. In general, pectinase supplements effectively compensate for the lack of energy, which increases the nutrient uptake and the structure of the gut. The best performance was observed in the groups treated with the enzyme, especially under moderate energy deficiency. These results indicate that the use of pectinase with diets low in energy or containing oats is able to develop broiler growth rate and make it a promising strategy for sustainable poultry production.

Keywords: poultry, pectinase, oat, diet.

Introduction

In modern commercial poultry production, feeding efficiency and utilization of nutrients by broiler chickens are critical factors that detect growth rate, production cost, and overall profitability. Since that poultry feed makes up about 60-70% of total production costs, formulating a good feed is most important, the addition of probiotics, enzymes, antibiotics, prebiotics, or natural products can contribute to

the improvement of the bird's use of meat [2, 3]. In recent decades, poultry nutrition research has largely focused on reducing crude protein or metabolizable energy levels in feed as a strategy to lower feed costs and minimize environmental impact [36,48]. Cereals such as maize, wheat, and oats are commonly used as a primary source of energy in broiler feeds. However, their nutritional value is often limited by the showing

of NSP, which expand and encapsulate nutrients, increase intestinal viscosity, and inhibit the action of exogenous digestive enzymes. The use of exogenous enzymes has also become a common feeding strategy in poultry nutrition. Pectinase enzymes have garnered significant attention for them with the ability to break down non-starch sugars and improve nutrient digestibility. These enzymes particularly effective in oat-based feeds, where they break down pectin and other complex fibres, thereby reducing digestive viscosity. Non-starch glycolytic enzymes are added to poultry feed give out complex carbohydrates found in plant cell walls. These carbohydrates consist primarily of components such as arabinoxylan Ates, pentoses, and beta-glucans, which are abundant in cereal-based ingredients [32]. Non-starch glycolytic enzymes increase poultry growth rate by limiting gut viscosity caused by non-starch sugars and releasing food trapped within plant cell walls, thus enhancing their availability for digestion and absorption [33].

Supplementing enzymes to broiler feed is able to increase the efficiency of feed while decreasing the harmful impact of non-starch polysaccharides (NSPs) on chicken growth rate and performance [13,19]. However, it has been reported that an enzyme blend including carbohydrates and proteases enhances the utilization of energy, phosphorus, protein, and calcium in laying broiler ducks, hens, and Japanese quail [8,17]. Also [6,28] protease supplementation enhances energy digestibility and crude protein in low – CP feed in broiler chicks. Despite studies reporting an increase of about 100kcal/kg in energy digestibility [22, 29]. The result of protease supplementation on energy metabolizable has not been thoroughly investigated. However, enzymes the addition indicated to increase ME has been shown to

improve ME employment in foodstuffs with reduced energy content [29].

Materials and Methods

Enzyme feed additive with macerating effect

Description: red-yellow powder with a grayish tinge of color with a specific odor.

Ingredients: 1 g contains the active ingredient: pectate trans-eliminase (pectin lyase) -5000±500 units.

Filler: wheat fodder bran.

Purpose: to increase the nutrient uptake and metabolism of food in feeding farm poultry by processing the structure of plant tissues and destroying intercellular pectin bonds

Design of experimental

350 Rosse-308 old chicks were divided and randomly distributed into 7 treatment groups (5 replicate per group, with 10 birds per replication), and initial body weight were recorded. Feed manufacturing and rearing chicks was carried out in the field animal production about period 35 days.

Treatment was arranged as follows:

- 1- T1= Control diet.
- 2- T2= Control diet – 150kcal energy
- 3- T3 =Control diet -300kcal energy
- 4- T4 = T2+ 300gm of pectinase enzyme
- 5- T5 = T3+300gm of pectinase enzyme
- 6- T6 = 30% oat-based diet – 150 kcal energy with 300g of pectinase enzymes
- 7- T7 = 30% oat-based diet – 300 kcal energy with 300g of pectinase enzymes.

Feed formulation

During the experimental feed preparation (starter and grower) were obtained from the animal production feed factory, At the

College of Agriculture Engineering Science, University of Duhok.

Table 1: Ingredient and composition of the basal starter and grower diets as percentage.

Ingredient %	Corn –based Diet		Oat –based Diet 30%	
	Starter	Grower	Starter	Grower
Corn	35	37.6	16	20
Wheat	13	18	9	9
Wheat bran	8	3	5	4
Oat	6	5	30	30
Soybean meal	33	30	32	29
Vegetable oil	0.9	2	3	3.5
Limestone	1.7	1.5	1.7	1.5
Dicalcium phosphate	0.6	0.4	0.6	0.2
Premix ¹	2.5	2.5	2.5	2.5
Estimated Chemical Composition %				
ME (Kcal/kg)	2950	3103	2947	3100
CP(Crud protein)	22.2	20.7	22	20.78
CF (Crud fiber)	3.9	3.34	6.1	6
Fat	3.1	4.1	4	5
Linoleic acid	1.4	1.9	2.3	2.6
Lysin	1.46	1.3	1.46	1.3
Methionine	0.58	0.57	0.59	0.57
Tryptophan	0.36	0.34	0.34	0.32
Methionine + cystine	0.93	0.9	0.9	0.89
Threonine	0.96	0.9	0.94	0.89
Arginine	1.5	1.4	1.49	1.34
Calcium	1	0.87	1.04	0.86
Phosphor	0.5	0.43	0.52	0.45
Sodium	0.21	0.20	0.20	0.2
Chloride	0.18	0.19	0.25	0.26

¹Vitamin concentrate provide per kg of feed: vitamin A, 400000 IU; VI D3 160000 ; Vit E 1200mg; K3100 mg; B1 120mg; B2 280mg; B6 160mg; B12 1400mg; Biotin 4mg; Niacin 1600mg; Folic Acid 40mg; Calcium D-pantothenate 600mg; choline chloride 12000mg; ² concentrated mineral drops provide per kg of feed: Iron (Fe) 2000mg; Copper (Cu) 400mg; Zinc(Zn) 2400mg; Manganese (Mn)3200mg; Iodine (I) 40mg; Sodium Selenite(Se) 10mg;

Performance data

Performance data body weight, body weight gain and feed conversion ratio were mentioned at ten, twenty-four and thirty-five days. During the experimental according to the guide of Ross 308 we provide the light programs, feeding, humidity and temperature from 1 to 35 days. Digestibility parameter and serum biochemical in 24 days, 2 birds per replicate were selected randomly, move on to the blood draw section and slaughtered, and then 5 ml of blood was taken from the jugular vein for blood serum parameter. Using the procedure of blood sample analysis in the laboratory.

Histological analysis

In the intestinal sampling from the jejunum were taken about 2 cm from each bird of replication on day 24. Then stored in formalin 10% after being flushed by buffered saline for at least 24 hours, then the dehydrated sample was imbedded in paraffin followed by standard microanatomy practices. Section the sample were cut in 5 mm and stained with hematoxylin and eosin stain. Samples were scanned and photographed by using (dino- eye-microscope digital camera) at 10 times of magnification, these digital cameras used to find

out and reading intestinal tissue, measuring (villi height, muscle thickness, crypt depth, tip, base, VH/CD and surface area) 10 times per each section of intestinal tissue was measured and evaluated at 10X magnification which was used for the scanned picture

Blood sampling

Taking blood sample in jugular vein on the day days 24 of age 2 birds for each replicate in the purpose of serum biochemical analysis, containing the following parameter

- 1- Total protein
- 2- Albumin
- 3- Creatinine
- 4- AST and ALT

After separating of serum from whole blood by centrifuge which was used to analyze serum biochemicals calorimetric enzymatic method according to the protocol of commercial kits procedure and applied in the Vin hospital and Medical Complex in Duhok governorate.

Statistical analysis

In a completely randomized design, all the collected data were analyzed using SPSS software [41]. one-way ANOVA analysis of variance was used to statistically examine all the results. Duncan's multiple range tests were used to identify different among means at ($p < 0.05$)

Results

Growth performance

The effect of different diets of broiler fed with low energy and high in fibers containing different levels of pectinase enzymes on the live body weight, feed intake and feed conversion ratio at 10, 24, 35 days old is shown in (Table 2), resulted significantly ($p < 0.05$) different treatments during experimental study.

At 10 and 24 days old chick were fed control diet (T1) and (T6) receiving 30% oat-based diet with a 150 kcal reduction and 300gm of pectinase enzymes showed significantly

($p < 0.05$) increased live body weight compared with energy -restricted groups (T3 and T7). Also from day 36 (T6) recorded the heaviest body weight (1936.35g), followed by those in T1 (1846.44g), while the lowered body weight was indicated in the group fed the control diet with 300 kcal reduction T3, this means that energy restriction reduces growth performance. The inclusion of pectinase enzyme (T4 and T5) slightly improved body weight compared with the non-enzyme, low-energy groups, suggesting a beneficial result of adding enzymes at

feedstuff utilization . during the experimental study body weight gain effected significantly($p<0.05$) by nutrient treatment.

The highest gain was recorded in the T6 group, which received the oat-based diet with moderate energy reduction, followed closely by the control diet (T1). Chicks fed diets with a 300-kcal reduction (T3 and T7) had the lowest weight gain, confirming the negative effect of severe energy restriction. Enzyme supplementation in the low-energy diets (T4 and T5) enhanced body weight gain compared with their corresponding non-supplemented groups (T2 and T3). And indicated that pectinase enzyme followed improved and able to degrade non-starch polysaccharides, thus enhancing digestibility and energy release from feed ingredients. At 10 and 35 days of age, feed intake appeared significant($p<0.05$) with variation between treatments. The highest feed intake was observed in chick fed the enzymes supplemented diets (T5) and those in T6, while the lowest intake occurred in T7. This recommend that moderate integration of oat and enzyme supplementation may improve palatability or digestive efficiency. At day 24, the differences in consumption feed were not meaningful ($p<0.05$), indicating similar feed intake during mid-growth. Feed conversion ratio increased significantly ($p<0.05$) by nutrient treatment at all experimental periods except day 24. The most efficient feed utilization (lowest FCR) was recorded for birds in T6 (1.03, 1.34,

and 1.41 at 10, 24, and 35 days, respectively). Conversely, the poorest FCR was observed in T4 at day 35 (1.56). Birds fed the enzyme-supplemented diets (T4 and T5) exhibited improved FCR values compared with their non-enzyme counterparts (T2 and T3), reflecting the positive impact of pectinase on nutrient availability. The superior performance of T6 indicates that partial replacement with oats combined with a moderate reduction in dietary energy can maintain growth and feed efficiency, likely due to better fiber digestibility and energy utilization.

Overall, reducing dietary energy by 150 kcal had a negligible effect on performance, while a 300-kcal reduction led to marked declines in feed conversion ratio and body weight. Supplementation with pectinase enzyme in low energy diets enhanced growth performance, aligning with previous reports that enzymes enhance nutrient digestibility by hydrolyzing complex polysaccharides and reducing gut viscosity. The inclusion of 30% oats with moderate energy reduction (T6) produced the best overall results with regard to FCR, live body weight and weight gain ($p<0.05$). These findings suggest that oats, when combined with appropriate enzyme supplementation or balanced energy levels, can serve as an effective ingredient in broiler diets without compromising performance.

Table 2: production performance of broiler fed diet low energy and high in fibers contains different level of pectinase

Treatment	Live body weight (g)			Body weight gain (g)			Feed intake (g)			FCR		
	10	24	35	10	24	35	10	24	35	10	24	35
T1	265.5a	1028.3a	1846.4ab	261.0a	984.3a	1855.4ab	275.8a	1350.6a	2753.4a	1.05	1.37	1.48c
T2	265.0a	1020.4a	1828.6ab	260.5a	976.4a	1828.6ab	268.9a	1363.7a	2756.3a	1.03	1.39	1.50bc
T3	251.3ab	960.0b	1710.7c	246.8a	916.0b	1710.7c	269.9a	1295.8b	2610.1b	1.09	1.41	1.52ab
T4	270.9a	999.6ab	1755.7bc	266.4a	956.6a	1755.7bc	281.6a	1353.0a	2740.6a	1.05	1.41	1.56a
T5	263.8a	995.1ab	1807.6ab	259.3a	951.1a	1807.6ab	270.4a	1344.5a	2793.6a	1.04	1.41	1.54ab
T6	272.7a	1043.2a	1936.3a	268.2a	999.2a	1936.3a	276.8a	1348.0a	2732.1a	1.03	1.34	1.41d
T7	240.5b	946.7b	1742.8bc	236.0b	902.7b	1742.8bc	256.6b	1281.5c	2674.7a	1.09	1.42	1.53ab
SEM	2.978	8.514	19.266	2.978	8.514	18.857	2.307	8.281	20.099	0.00	0.090	0.009
P value	0.029	0.029	0.098	0.114	0.009	0.009	0.032	0.250	0.014	0.01	0.241	0.0001
F value	2.809	2.809	2.012	1.914	3.623	3.623	2.741	1.398	3.286	3.37	1.424	11.230

a, b, c – mean values on the same column not sharing a superscript are significantly different. ($p < 0.05$). SEM=Standard error of means, T1= Control diet. T2= Control diet – 150kcal energy. T3 =Control diet -300kcal energy. T4 = T2+ 300gm of pectinase enzyme. T5 = T3+300gm of pectinase enzyme. T6 = 30% oat-based diet – 150 kcal energy with 300gm of pectinase enzymes. T7 = 30% oat-based diet – 300 kcal energy with 300gm of pectinase enzymes.

Histomorphology

In broiler chicken the jejunal histomorphology was significantly ($p < 0.05$) effected by nutritional parameter (Table 3). In birds fed the 30% oat-based diet with 150 kcal restricted energy the highest villus was indicated (T6, 1726.61 μm). And the group T4 supplemented enzymes followed by (1553.16 μm). but T5 found the lowest height villi (1460.33 μm). From T6 and T7 obtained crypt depth was greatest and T4 and T5 found the lowest crypt depth. T6 (231.05 μm)

significantly increased ($p < 0.05$) in Muscle thickness and villus surface area (329,900.16 μm^2) compared to the other groups. The villus height to crypt depth ratio (VH/CD) in the enzyme-supplemented groups in T4 was the highest and indicated refined intestinal morphology. Overall, the T6 group exhibited superior intestinal development, whereas adding enzymes in treatments T4 and T5 enhanced villus structure within low-energy diets

Based on the findings, implementing a 30% oat-based diet combined with a 150-kcal

reduction in energy (T6) optimized the intestinal morphology of broiler chicks by enhancing villus height, muscle thickness, and surface area, which suggests improved nutrient absorption and enhanced gut health.

Furthermore, incorporating pectinase enzyme (T4 and T5) improved the villus height-to-crypt depth ratio, indicating that enzyme supplementation aided in better digestion and nutrient utilization within low-energy diets.

Table 3: intestine morphology of broiler fed diet low energy and high in fibers contains different level of pectinase

Treatment	Villi heigh µm	Crypt depth µm	Muscle thickness µm	Villi Tip µm	Villi Base µm	VH/CD	Surface area µm ²
T1	1494.34 ^{bc}	187.35 ^b	184.67 ^{bc}	145.21	155.37 ^c	8.41 ^{bc}	247058.88 ^{bc}
T2	1475.35 ^c	191.00 ^b	170.26 ^c	139.98	187.27 ^a	8.33 ^{bc}	227951.43 ^{cd}
T3	1518.31 ^{bc}	204.14 ^{ab}	178.48 ^c	155.29	163.39 ^{bc}	8.05 ^{cd}	255406.85 ^b
T4	1553.16 ^b	163.82 ^c	175.07 ^c	136.95	173.67 ^{ab} _c	9.9 ^a	242937.44 ^{bcd}
T5	1460.33 ^c	168.35 ^c	149.58 ^d	147.28	170.75 ^{ab} _c	9.18 ^{ab}	218776.30 ^d
T6	1726.61 ^a	215.39 ^a	231.05 ^a	149.83	155.62 ^c	8.44 ^{bc}	329900.16 ^a
T7	1496.97 ^{bc}	215.06 ^a	200.56 ^b	139.74	177.17 ^{ab}	7.17 ^d	257733.01 ^b
SEM	10.148	2.739	2.771	2.293	2.574	0.126	3793.647
P value	0.0001	0.0001	0.0001	0.337	0.006	0.0001	0.0001
F value	14.001	9.457	15.345	1.143	3.058	7.383	16.476

a, b, c – mean values on the same column not sharing a superscript are significantly different. ($p < 0.05$). SEM=Standard error of means, T1= Control diet. T2= Control diet – 150kcal energy. T3 =Control diet -300kcal energy. T4 = T2+ 300gm of pectinase enzyme. T5 = T3+300gm of pectinase enzyme. T6 = 30% oat-based diet – 150 kcal energy with 300gm of pectinase enzymes. T7 = 30% oat-based diet – 300 kcal energy with 300gm of pectinase enzymes.

Relative organ weight

At 24 days of age the effect of reducing energy and pectinase supplementation on the organ to body weight ratio in broiler chicks is shown in table (4). Achieved that none of the measured organs increased ($p < 0.05$) by dietary therapy. The relative weights of the gizzard and proventriculus covered from 3.52% to 4.23%, with the lowest in T5 and the highest value indicated in T6 and T7. Also in T6 showed a slight numerical increase in liver weight range between 2.71% to 3.18%.

The absence of significant differences between treatments suggests that a slight

reduction in dietary energy and the addition of pectinase enzyme did not adversely affect internal organ development. These results indicate that the digestive and immune organs of broiler chicks maintained normal growth and function under controlled and low-energy conditions. The slight increase in intestinal weight observed in the group containing the enzyme (particularly groups T4 and T5) may be attributed to better nutrient absorption and digestion of the intestinal tract in broiler chicks, supporting the histological findings indicating improved intestinal structure. Overall, the results confirm that enzyme supplementation

and the substitution of a small portion of the feed with oats should be safely employed in poultry nutrition due to the absence of a negative effect on internal organ development.

Table 4: Body organs weight ratio of broiler fed diet low energy and high in fibres contains different level of pectinase

Treatment	Gizzard and proventricular %	Liver %	Small intestine weight %	Spleen %	Bursa %
T1	4.00	2.71	5.94	0.09	0.16
T2	3.89	2.89	5.77	0.09	0.23
T3	4.13	2.88	5.78	0.1	0.18
T4	4.19	2.73	6.73	0.07	0.21
T5	3.52	3.08	6.16	0.07	0.17
T6	4.23	3.18	6.04	0.07	0.18
T7	4.23	2.96	6.6	0.1	0.22
SEM	0.111	0.068	0.134	0.005	0.010
P value	0.630	0.535	0.349	0.629	0.557
F value	0.730	0.861	1.171	0.730	0.829

a, b, c – mean values on the same column not sharing a superscript are significantly different. ($p < 0.05$). SEM=Standard error of means, T1= Control diet. T2= Control diet – 150kcal energy. T3 =Control diet -300kcal energy. T4 = T2+ 300gm of pectinase enzyme. T5 = T3+300gm of pectinase enzyme. T6 = 30% oat-based diet – 150 kcal energy with 300gm pectinase enzymes. T7 = 30% oat-based diet – 300 kcal energy with 300gm of pectinase enzymes.

Serum biochemical

The effect of Serum biochemistry of broiler fed diet low energy and high in fiber containing different levels of pectinase in 24-day old broiler chicks is shown in (Table 5). Serum aspartate aminotransferase (AST) activity differed increase significantly ($p < 0.05$) Between the experimental study, with the highest number resulted in treatments T6 and T7, and the lowest in treatment T4. However, T6-treated birds recorded a slightly higher amount of total protein (3.15g/Dl) and globulin (1.67 g/dL) compared to the standard group and other treatments. These presenting investigate

reducing dietary energy and added pectinase enzymes did not influence affect kidney and liver function, and T6 which contains an oat-based diet led to enhanced protein metabolism and immune function in meat chicken.

The current results indicate that serum biochemical values were generally within the normal physiological range for broiler chicks, demonstrating that neither energy reduction nor enzyme supplementation caused any metabolic stress. The reduced aspartate aminotransferase (AST) levels in the enzyme-treated group (T4) suggest a positive effect of pectinase on liver function through improved nutrient digestion

and reduced metabolic load. The slight enhancements in globulin and total protein amount in birds fed an oat-based diet (T6) may reflect enhanced protein synthesis and immunologic response. Overall, the results

show that the addition of pectinase enzymes or the inclusion of oats in low-energy diets supports liver health and normal metabolic function in broiler chickens.

Table 5: serum biochemicals of broiler fed diet low energy and high in fibers contains different level of pectinase

Treatment	AST- I.U./L	ALT I.U./L	Cretonne mg/dl	uric Acid mg/dl	Total. Protein g/dl	Albumin g/dl	Globulin g/dl
T1	212.66 ^{bc}	1.68	0.056	4.86	2.72 ^{ab}	1.43	1.28 ^b
T2	230.14 ^{abc}	2.08	0.052	5.24	2.67 ^b	1.44	1.23 ^b
T3	228.76 ^{abc}	2.04	0.068	3.96	2.69 ^{ab}	1.42	1.27 ^b
T4	201.12 ^c	1.5	0.062	4.84	2.60 ^b	1.37	1.23 ^b
T5	237.24 ^{ab}	1.44	0.046	4.56	2.67 ^b	1.48	1.22 ^b
T6	250.00 ^a	2.26	0.084	4.94	3.15 ^a	1.34	1.67 ^a
T7	249.20 ^a	2.14	0.054	4.52	2.90 ^{ab}	1.42	1.56 ^{ab}
SEM	4.44	0.113	0.005	0.250	0.059	0.022	0.050
P value	0.013	0.302	0.699	0.914	0.163	0.679	0.065
F value	3.324	1.272	0.638	0.333	1.680	0.665	2.274

a, b, c – mean values on the same column not sharing a superscript are significantly different. ($p < 0.05$). SEM=Standard error of means, AST= Aspartate aminotransferase, ALT = Alanine aminotransferase T1= Control diet. T2= Control diet – 150kcal energy. T3 =Control diet -300kcal energy. T4 = T2+ 300gm of pectinase enzyme. T5 = T3+300gm of pectinase enzyme. T6 = 30% oat-based diet – 150 kcal energy with 300gm pectinase enzymes. T7 = 30% oat-based diet – 300 kcal energy with 300gm of pectinase enzymes.

Digestibility

The effect of reducing dietary energy and adding pectinase enzymes on absorption efficiency, As shown in table (6) showed a significant ($p < 0.05$) difference in ash and fat content among treatment, but fiber and protein percentage not appear any different as a result of the experiment. The lower values for T6 and T7 recorded in ash and fat contrast the control

group, the data presented from including oat and reducing energy in diet will decrease fat deposition and mineral content in the meat, which may improve meat leanness and consumer health value, while remaining similar protein and fiber levels across treatments. whereas the highest fat content appeared in T2 (98.65%).

Table 6: nutrient digestibility of broiler fed diet low energy and high in fibers contains different level of pectinase

Treatment	Protein %	Fat%	Fiber %	Ash%
T1	77.72	96.02	53.43	86.83
T2	77.44	98.65	53.64	83.57
T3	77.84	97.27	58.67	86.40
T4	77.52	97.94	60.68	84.64
T5	77.23	95.35	51.77	86.31
T6	76.06	86.10	49.71	76.73
T7	76.81	85.35	49.60	77.06
SEM	0.271	0.976	1.229	0.869
P value	0.650	0.0001	0.093	0.0001
F value	0.703	24.520	2.044	8.228

a, b, c – mean values on the same column not sharing a superscript are significantly different. ($p < 0.05$). SEM=Standard error of means, AST= T1= Control diet. T2= Control diet – 150kcal energy. T3 =Control diet -300kcal energy. T4 = T2+ 300gm of pectinase enzyme. T5 = T3+300gm of pectinase enzyme. T6 = 30% oat-based diet – 150 kcal energy with 300gm of pectinase enzymes. T7 = 30% oat-based diet – 300 kcal energy with 300 gm of pectinase enzymes.

Discussion

[24] Noted when adding amylase, protease and xylanase to the diet enhanced broiler growth performance. This improvement was likely linked to healthier intestinal structure, increased ileal nutrient digestibility, structure, and functional potential of the intestinal flora in twenty-one-day-old broilers. [39] resulted in the fact adding pectinase 1000U/kg had no significant effect on any of the feed intake, FCR, body weight gains and final body weight measurements. In contrast, lowering the metabolizable energy (ME) level from the standard diet to the 100 kcal lower than STD(E100) diet led to a marked decline in FBW, BWG, and FCR, along with a notable rise in feed consumption throughout the case period. [35] also showed adding a pectinase-containing an enzyme blend (200 g/ton) to feed reduced by ME 40 kcal per kg didn't enhance FBW or FCR. In contrast, several studies, including those by [26,31] found that pectinase supplementation improved broiler performance. Moreover, many researchers have shown that broiler growth

responses can be significantly enhanced by enzyme-supplemented diets, even when dietary ME levels are lowered, particularly when enzyme mixtures are used. [15] reported that adding β -galactosidase or lipase to wheat-based broiler diets produced minimal effects on overall performance. The low availability of substrate for β -galactosidase may have prevented any measurable benefits. A multi-enzyme product containing pectinase—but lacking lipase and β -galactosidase—allowed researchers to focus specifically on the effects of non- β -galactoside polysaccharides present in soybean and other plant proteins. [25] found that supplementing diets with a multi-enzyme blend increased BW, improved FCR, with contributed to better energy utilization, agreement with [1] and [8]. Improvements in weight gain and body weight with multienzyme inclusion with perhaps linked to enhanced nutrient release and absorption resulting from better diet digestibility, as noted by [10, 14,20]. Nonetheless, the response to multienzymes

varies according to diet composition and the specific enzymes used [49]. Previous research has shown that multienzyme additives can increase weight gain and feed efficiency while lowering feed consumption. Significant development responses among 7 and 21-days' old have been caused by amylase activity and enzymes that break down non-starch polysaccharides [16,23].

In general, enzyme supplementation and oat addition in feds enhanced the growth rate and intestinal development in broiler chicks. [9] The villus length increased when added with 0.1% of multienzymes to the diet compared with the other enzymes levels, and the villus height reached to 32.6%. [24]. Added diet with amylase, protease and xylanase increases growth performance, likely as a result of better gut morphology, enhanced ileal nutrient digestibility and functional side view of the cecal microbiota in 21-day day broiler age. [45]. on the other hand, [24] presents the study by including xylanase, amylase and protease in the fed of broiler resulting in an increase gut structure in young broiler and proved to have taller intestinal villi and shorter crypts from 21-day-old. [40] showed than the corn-wheat-soybean basal diet (CWS) and corn-wheat-soybean canola basal diet (CWSC) led to decreased the villus height-to crypt depth in the duodenum and in jejunum contrast with the CS diet. In contrast, this ratio increased significantly ($p < 0.05$) this ratio in the duodenum, jejunum and ileum by the addition of enzymes, also indicating wider duodenum villi.

[34] feeding broiler with a Rye-based diet resulted in increased microbial activity in the gut, which in turn altered the morphology of the intestinal wall such qualification in mucin amount or composition led to help explain the enhanced nutrient uptake in the small intestine. Similarly, [43] who indicated during adding

enzymes to broiler chicks diet will be increase in villus and crypt dimensions as well as a higher density of goblet cells. In contrast, presented by [27,45] showed that enzymes xylanase supplementing a wheat-based diet did not measurably change happened in villus height or crypt depth in the duodenum, ileum and jejunum of chicken meat.

. [12] presented that adding a weakened diet with non -starch degrading enzymes enhanced preserving intestinal length, maintaining it corresponding to that broiler fed the normal control diet. furthermore, [16,45] presented that supplementation of enzymes in a low -protein diet in broiler could be lower relative weight and length of a decrease the relative length and weight of the gut compared to the standard group. However, according to [42] supplementation of multi-enzymes in broiler chicks by feeding of low protein diets at six weeks of age, the small bowel length declined and the intestinal weight reduced. [30] Presented that adding mixture enzymes into broiler feeds there was no effect on comparative weight of immune organs, including bursa of Fabricius, spleen and thymus gland. [7] Presented of supplementation the multienzymes at different level of 0.1% and 0.2% reasons to lowered in AST, ALT, TAC and MDA compared to the control treatment .on the other hand, the enzymes significantly increased β -globulin level rate but there is no change in resulted from total protein, albumen and globulin.

In general, supplementing oat and enzymes in low energy diet showed to produce leaner meat without negatively affecting protein content or overall meat quality. [46] resulted that adding diet contain multi-enzymes significant improvement ($p < 0.05$) in crud protein digestibility. Unlike ether extract, crude Fiber and dry matter digestibility showed no indication among the treatments. Similarly, [37] indicated that mixture enzymes added to the

diet, which contain this enzyme protein digestibility improved, this approved adding multi-enzymes to a low ME diet resulted increased significantly ($p<0.05$) in protease and lipase activity compare to the control group. while amylase activity remained unaffected by the treatments. Also (5) resulted in nitrogen digestibility in broiler chickens increased by using on amylase and xylanase combination. accordingly, [47] observed that given NSPase to the animal in a significant increased ($p<0.05$) amylase and lipase activity compared to not

receiving enzyme supplementation. [18] resulted that adding enzymes such as carbohydrase's and phytases – either individually or in combination, to the meat chicken diet can increase growth rate and nutrient absorption even if it contains a low energy level in the diet. These enzymes also enhance intestinal morphology and overall energy efficiency, causing to lower nutrient wastage in the climate and reduced nutrient expenses [4,38,11,44].

Conclusion

The present that lowering dietary energy by 150 kcal had minimal impact, while a 300-kcal reduction negatively affected growth performance. adding 300gm of pectinase enzyme with low energy enhanced growth performance of body weight, feed intake, feed conversion ratio and intestinal morphology. during the experimental we indicated 30% oat-based diet with 150kcal reduction (T6) have the best results effect on increasing nutrient utilization, growth rate and gut structure. In additional, pectinase enzyme has positive effect of liver function by improving nutrient digestion and reducing metabolic load by the lower AST amount in the enzyme-treated group(T4). immune response well enhanced by protein synthesis during slightly higher total protein and globulin amount in fed that contain oat-based diet (T6).

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