EVALUATION OF DRIED TOMATO POMACE AS UNCONVENTIONAL FEED IN BROILERS DIET: NUTRITIONAL, ZOOTECHNICAL AND IMMUNE PARAMETERS

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Abstract

The current study was carried out to evaluate the impact of dietary dried tomato pomace (DTP) inclusion on the zootechnical performance parameters ,carcass traits and immune status of broiler chickens when included at two levels (8&16%) with or without commercial enzyme (MZ) supplementation in a maize-soybean diet. One –hundred and eighty-one- day old unsexed Cobb broiler chickens were arranged in complete randomized 3X2 factorial design in 35- day trial. The nutritive value for the DTP were determined and accordingly, two isonitrogenous – isocaloric experimental diets (starter and finisher) were formulated to which the % of DTP was 0(C0), 8 (DTP8) & 16 (DTP16) and for each level the MZ supplementation was added either 0 or 200gm/ton. Zootechnical parameters (body weight development, feed consumption and Feed conversion ratio) were determined. Phagocytic activity, phagocytic index and HI titers for Newcastle Disease (NDV) were selected parameters for immune response. The results revealed that 16% DTP with MZ produced highly significant ($p<0.05$) increase for feed intake, body weight and significant ($p<0.05$) decrease for Feed conversion ratio in comparison to the control or the 8%DTP with or without MZ. However, the low level of DTP surpassed all non- supplemented MZ groups in final body weight and FCR. Phagocytic activity and index, and antibody production against NDV were not affected by the supplementation of DTP at both levels, meanwhile, the same groups fed DTP with MZ showed significant ($p<0.05$) improvement for all selected immune parameters. Carcass traits demonstrated the groups fed DTP at any level with MZ posses significant ($p<0.05$) lowered abdominal fat compared with the non-supplemented groups. The economic study confirmed that DTP could be successfully incorporated in broilers diet at the highest level (16%) on condition that it must be included in a well-balanced diet and it is used with the suitable enzyme combination.

Key words: *Broilers, Dried tomato pomace, Immunity, Multi- enzyme, Performance, unconventional feedstuff*

1. INTRODUCTION

Poultry industry sector is one of the main growing agricultural industries in Egypt, where investments in this industry are about 18 billion LE and other supportive industries are with an average of 1,200,000,000 L.E. annually and expanding as well. The ever-increasing prices for most of the imported raw materials namely maize and soybean incorporated in the poultry feed and the essential deficit as for growing competition with the human beings for the same food items, necessitate the search for alternative feed sources to reduce the feed cost which accounts for 60-70 % of the total cost of poultry production. So, any attempt to reduce the feed cost is inevitable especially the methods adopt utilizing the use of low cost locally available agro-industrial by-products in poultry feed. Farm crop residues and industrial wastes impose environmental problems, if they are not reused. Many of these by –product proved to be beneficial as unconventional feedstuffs for different categories of livestock. In Egypt, it is estimated to be more than 25 million MT feed from various crops with tomato production (*Lycopersicun esculentum*) surpassing all fruits and vegetable crops [1].The amount (MT) estimated for tomato production is nearly 4 694 000 with an expected waste of 50%. As tomato by-products are highly variable products in many aspects such as physical form, chemical composition, and subsequent nutritional value according to the nature of the leftover waste produced by the methods of the processing. The common names of the products are pomace, pulp, skins, seeds, waste, etc. Tomato seeds have a high protein (25-28% DM), fiber (54% ADF) and fat (20-24% DM) content [2, 3]. Tomato pomace (TP) is usually the name of tomato by-products from ketchup and juice factory

contains pulp, skins, and seeds. The evaluation of the possible use of TP in poultry diets has been long tried and proved to be suitable for inclusion at certain levels and with proper treatment [4 , 5 , 6, 7, 8]. It was found that replacing up to 15% tomato seeds for corn and SBM had no any adverse effects on chick (8 to 21 d) weight gain, feed intake, or feed efficiency considering true digestible amino acid and TMEn basis on diet formulation [2]. The high amount of fiber and its nature represent a limiting factor in inclusion TP in broilers diet [9].The cell wall is considered the main obstacle for digestive enzyme to get to nutrients which suppress digestion, absorption and consequently gain [10]. [7] studied the impact of feeding different levels of dried tomato pomace (0, 8, 16 and 24%) either with or without enzyme supplementation and found that inclusion of DTP up to 8% to broiler diets had comparable effects on performance and carcass characteristics compared to control, while the enzyme had a significant effect on BWG, carcass weight and yield of abdominal fat. [11] indicted that up to 15% inclusion of untreated tomato pomace induced similar effect in broilers diet as compared to control. [12] reported that tomato pomace can be used in broilers rations at a level of 5% without multi-enzyme and up to 10% with multi-enzyme supplementation with no adverse effect on broiler's performance.

Therefore, the objective of this study was to test the hypothesizes that the inclusion of DTP at two levels (8%&16%) in a balanced broiler diet with multi-enzyme supplementation has no significant influence on performance, immune status, carcass and organoleptic traits as well as no adverse impact on economical efficiency aspects.

2. MATERIALS AND METHODS

The current study was carried out in the NURB Experimental building belongs to the Nutrition and Clinical Nutrition Department, Faculty of Veterinary Medicine, Cairo University under the guidelines of the International Animal Care Institute Committee of Cairo University (IACUC) with approval number IF- CU 32/18.

2.1 Materials

2.1.1 Tomato pomace collection and preparation:

Fresh tomato pomace was obtained from Local Egyptian company produces ketchup (Hinez, Egypt) and was air dried under shade for 12h with frequent turning then complete drying was done in oven at 60^0C till constant weight. The dried TP (DTP) was grounded by hammer mill. Three samples from the DTP were analyzed for the proximate chemical composition (Table 1) according to [13]. The ME of DTP was calculated according to [14]. Methionine and lysine amino acids content of DTP were measured at Animal Health Research Institute, Dokki, Egypt using a spectrophotometer method of [15].

2.1.2 Experimental birds and management

One- hundred and eighty one- day old unsexed Cobb broiler chicks were purchased from a commercial hatchery and allotted into 6 experimental treatments, each of 3 replicates (10bird/ replicate) with nearly similar average initial weight. The experimental birds were housed in floor pens padded with fresh wood shavings and standard lightening program was adopted. The birds were vaccinated against Newcastle disease; Gumboro and IB virus according to the routine protocol applied in the experimental unite. Birds were offered mash feed and water ad libitum during the 35 day experimental period.

2.1.3 Experimental design and diets

The experimental design was 3X2 factorial arrangements, where the DTP was included in the diets at the levels of 0, 8&16% and each Level of DTP contained either 0 or 200g/ton of commercial multi-enzyme which contains amylase, cellulase, glucanase, lipase, pektinase ,phytase, protease , xylanase with the following concentration 700000, 600000, 700000,30000, 70000, 150000,300000, and 100000, respectively.

The starter and finisher diets were formulated according to the program of Vet Soft (EGYPT) to fulfill Cobb catalog requirements and to be isonitrogenous and isocaloric. The ingredients, composition and calculated analysis of the experimental diets are presented in Table (2).

2.2 Methods

2.2.1 Experimental measurements

2.2.2 Performance parameters

Changes in body weight and feed intake were recorded according to the period (2wk starter &3 wk finisher) and accordingly, body weight gain and, feed conversion ratio (FCR) were calculated.

2.2.3 Immunological status parameters:

2.2.3.1 Hummeral immunity:

For the detection the humeral immune response against Newcastle disease, 1 ml of blood samples was collected from wing vien without the use of anticoagulant from 2 birds per replicate for each treatment for serum preparation at the age of 14 and 23d. The Micro technique of heamagglutination Inhibition Test (HI test) was done according to the method of [16].

2.2.3.2 Cellular immunity:

For the determination of cellular immunity, phagocytic activity and phagocytic index was determined [17]. At the end of the experiment, 1ml of citrated blood was collected from 3 birds per treatment and certain amount of Candida albicans culture was added to 1ml of blood sample. The % of phagocytic activity (PA) was measured by counting the proportion of macrophages engulfing yeast cells in a random sample of 300 macrophages and hence, phagocytic index was also estimated.

2.2.4 Carcass traits and organoleptic test

For the assessment of the carcass and organoleptic traits of experimental birds fed different levels of DTP, 9 birds per treatment (3 / replicate) were chosen randomly at the end of the experiment and scarified to apply carcass traits. The birds were then coded and blindly distributed with designed questionnaire for data collection to determine organoleptic test [18].

2.2.5 Economic efficiency study

Total cost, total income and net revenue per bird as well as the economical efficiency % were determined.

2.2.6 Statistical analysis

The experiment was performed in factorial 3X2.The data was analyzed by two-way analysis of variance to determine the main effects (DTP inclusion and enzyme supplementation) and their interaction using the IBM SPSS [19] Statistics 20.0 software. Results are expressed as treatment means as pooled SEM. Differences were considered to be significant at $p<0.05$ and significant differences between means were separated by the Scheffe post- hoc tests.

Dried tomato pulp(DTP)	**DM %**	**CP %**	**EE %**	**CF %**	**Ash %**	**NFE %**	**Ca %**	**P %**	**Methionine%**	**Lysine%**
	92.3	23.4	10.6	29.4	4.5	32.1	0.39	0.56	0.90	3.1

Table 1. Proximate chemical analysis of tomato pulp (DTP)

Ingredient	**%**	**Starter**			**Finisher**		
		Control	**8%DTP**	**16%DTP**	**Control**	**8%DTP**	**16%DTP**
Corn		56.28	55.51	49.33	63.4	62.8	56.2
Soybean 48% Protein		35	23.97	20.06	28.2	19.08	16.24
Dried tomato pomace		----	8	16	-----	8	16
Corn gluten meal 60%		4	6	7	2.5	3	3
Di calcium phosphate		1.55	2.01	2.08	1.2	1.27	1.33
plant oil		----	1.96	3.15	1.8	3.79	5.21
Lime stone		1.8	1.25	1.15	1.6	1.15	1.06
DL-methionine		0.14	0.37	0.42	0.12	0.24	0.31
Sodium chloride		0.4	0.32	0.33	0.4	0.35	0.36
Vit. & Min. Premix		0.3	0.3	0.3	0.4	0.3	0.3
L-Lysine		0.17	0.23	0.11	0.12	0.01	----
Sodium bicarbonate		----	0.08	0.08	----	----	-----
Cost/ton			5418.99	5272.13		5009.45	4886.2
Nutrient	%						
Crude Protein		23.05	22 %	22	19.55	18	18
MEn Kcal / kg		3025.86	3025	3025	3200.24	3180	3180
Lysine %			1.43	1.43		1.05	1.18
Methionine %			0.75	0.77		0.55	0.58
Methionine + Cystine %			1.07	1.07		0.82	0.82
Calcium %		1.02	1.05	1.05	0.87	0.76	0.76
Available P %		0.5	0.5	0.5	0.41	0.38	0.38

*Supplied Per Kilogram Of Feed: 9000 IU of vitamin A, 20000IU vitamin D3, 18000IU vitamin E, 2000IU vitamin K3,3000IU Vitamin B3, 3000IU Vitamin B5, 1000IU Vitamin B9, 3000IU Vitamin B6. 200Mg ,Se,8000 ,Fe,100000 Mg Mn,100µg Se,100000Mg Zn, 10000 Mg Cu. E

Table 2. Ingredients, composition and calculated analysis for experimental diets

T	T	Parameters at 14d				Parameters at 35d			
DTP%	MZ	BW	G	FI	FCR	BW	G	FI	FCR
0	0	408.1	366.6	589.3	1.61	2122.5	2081.9	3818.4	1.83
	+	410.2	368.6	563.9	1.53	2314.4	2272.8	3886.5	1.71
8	0	413.5	372.7	577.7	1.55	2353.6	2312.8	4188.6	1.81
	+	433.3	398.2	592.2	1.51	2467.3	2426.2	4170.0	1.72
16	0	403.4	363.0	599.0	1.65	2008.1	1967.7	4210.9	2.14
	+	442.2	401.1	597.6	1.49	2585.5	2544.4	4022.5	1.58
Main Effects	SEM (n=3)[a]	8.4	9.7	12.2	0.003	42	38	55	0.022
	DTP%								
	0	409[b]	368[b]	563[b]	1.51[c]	2218[c]	2332[b]	3051[b]	1.73[ab]
	8	418[a]	385[a]	583[a]	1.52[b]	2410[a]	2370[a]	2033[b]	1.69[b]
	16	420[ab]	382[a]	551[c]	1.57[a]	2297[b]	2321[b]	3137[a]	1.75[a]
	MZ								
	0	408	367	563	1.56	2208[b]	2121[b]	4059	1.76
	+	418	389	572	1.51	2250[a]	2428[a]	4026	1.69
Probabilities	DTP%	*	*	*	**	*	*	*	NS
	MZ	NS	**	NS	*	*	**	NS	*
	DTP*MZ	NS	*	NS	NS	*	**	*	*

[a]Pooled standard error of the mean (n=number per treatment)

Each value represents the mean of 3 replicates (10 birds / replicate).

NS, non-significant.

*P≤ 0.05

**P ≤ 0.01

Table 3. Performance results of experimental birds in response to different dietary inclusion % of DTP and multi-enzyme

3. RESULTS

The % of the proximate chemical analysis of DTP used in the experimental trial (Table1) were 92.3, 23.4, 10.6, 29.4, 4.5, 32.1, 0.39,0.56, 2.9, 0.9 and 3.1 for DM,CP, E.E, CF, ash, NFE, Ca, P, methionine and lysine, respectively.

The results of the influence of the different inclusion% of dried tomato pomace (DTP) and multi-enzyme (MZ) supplementation on performance parameters such as the body weight development, gain, feed intake (g/bird), and feed conversion ratio during different experimental periods were presented in Table 3. The overall mortality rate during the 35d - experimental period was minor (not stated).The results of DTP inclusion without MZ supplementation indicated that the increase of DTP level up to 8% significantly (P≤ 0.05) improved body weight development, gain and feed conversion ratio (FCR) in different periods (starter and finisher) of the experiment compared with the other levels. The main effects of DTP inclusion indicated that the 8% level exhibited significant (P≤ 0.05) improvement in final body weight and numerical decrement in FCR while the main effects of MZ supplementation

showed significant (P≤ 0.05) increase in body weight, gain and non-significant increase for feed intake. The DTP inclusion at 16% with MZ supplementation achieved significant (P≤ 0.05) increase in gain and reduction in FCR values compared to all groups. Meanwhile, the interaction between DTP with MZ effects was highly significant (P≤ 0.01) for gain and significant (P≤ 0.05) for body weight, FI and FCR at the finisher period.

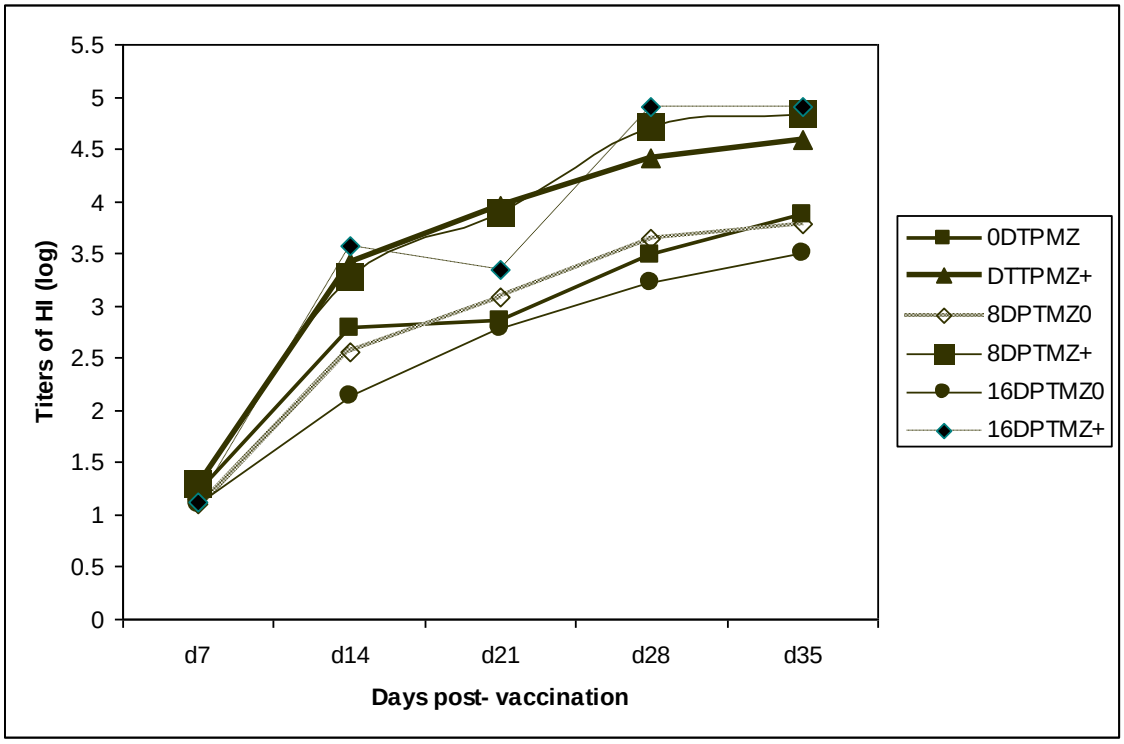


Fig. 1. HI titers against NDV at different experimental period

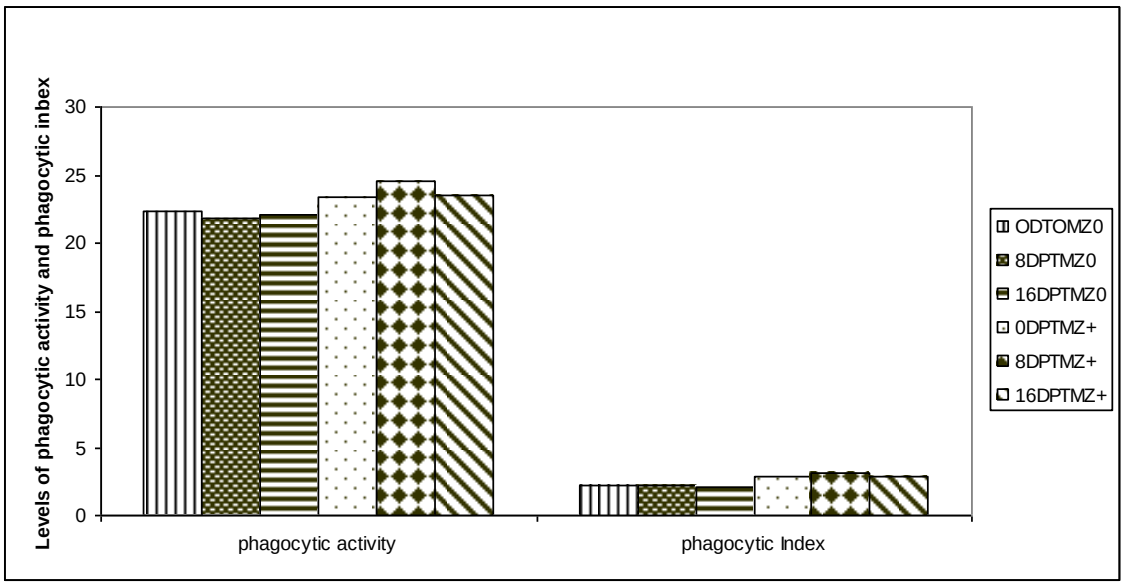


Fig. 2. Impact of different experimental treatments on phagocytic activity and index

The results of the impact of different levels of dietary DTP inclusion with or without MZ supplementation on different immune parameters (HI titers against NDV and phagocytic activity and index) of experimental birds were presented in Fig. 1and 2.The results revealed that DTP inclusion level did not significantly affect HI titers. However, the MZ supplementation was concurrently accompanied with significant ($p \leq 0.05$) gradual increase for HI titers against NDV and phagocytic activity with every elevation in DTP inclusion rate up till 8% DTP.

The results of carcass traits of the different experimental treatments were presented in Table 4. Dressing % was insignificantly differed between groups. Abdominal fat and giblets percentages were significantly ($P \leq 0.05$) differed between treatments. The main effects of DTP and MZ inclusions were significant ($P \leq 0.05$) at any level on abdominal fat compared to the 0 level of DTP inclusion. The increase on the level of DTP inclusion from 8 to 16% with MZ supplementation reduced abdominal fat by 79.2%and 65%.

The results of organoleptic test of the broilers chicken's meat either in raw or cooked at the end of the experimental period (Table 5) showed no significant difference in most of the tested criteria except some minor changes in the thigh color in raw meat (1 out of 9) and the flavor and tenderness in the groups fed 16% DTP with or without MZ supplementation.

The results of the economical study (Table 6) indicated that the inclusion of high level (16%) of DTP to the experimental diets without MZ supplementation had remarkably increased the total income and net revenue per bird as well as the economical efficiency % in comparison to all other groups. The % change of the economical efficiency compared to the control (0DTP&0MZ) revealed that the group fed 16% DTP and MZ surpassed all groups in improving the total income, net revenue per bird. Moreover, the % of the economical efficiency changes was 112.7 for the16% DTP and MZ group followed by fed 8% DTP and MZ (95.6).

4. DISCUSSION

The results of DTP analysis (Table1) showed that the average DM % was 92.3 which in the range between 90.0% [20] to 94.86% [11]. The DTP examined in this study recorded CP % of 23.4 on DM which was on average of the previously recorded values with its lower value of 17.32 and highest value of 28.4% [21 and 11], respectively. Different CF levels had been detected earlier on different samples of DTP which ranged from 27% [8] to 35% [20], and the DTP sample of this study was within this range (29.4%).The ME of DTP in this study was calculated according to [14] using the values of different nutrients and revealed the level of 2105 kcal/kg which was within previous recorded levels 1681kcal/kg to 3560 kcal/kg [21, 12], respectively. The lysine content of the sample was 3.1 % which was higher than the values obtained by [3] nevertheless, [22] reported that tomato seeds' protein contains approximately 13% more lysine than soy protein. However, the changes in the chemical composition for various samples may be attributed to many factors among them, the nature of the sample itself, more seeds tends to increase CP levels, while more CF and ash tend to decrease energy levels. Moreover, the fluctuation in the DM contents recorded from different studies might be the contribution of the tomato crop diversity raised in different soils as well as to the methods applied in processing [23].

The performance results (Table3) are in agreement with several studies [6, 7, 24] which indicated that higher inclusion levels of DTP with no exogenous enzyme significantly ($P \leq 0.05$) had a negative impact on performance parameters. The higher level of CF content as well as, the nature of such CF of DTP might contribute to the aforementioned results as the deficiency of the available energy needed for growth forced the birds to respond by increasing feed intake [25]. The groups supplemented with DTP and multi-enzyme (MZ) showed the significant increase ($P \leq 0.05$) in final body weight, gain and significant decrease ($P \leq 0.05$) in FCR in comparison with the relevant non- supplemented groups. [8] found that inclusion of DTP up to 8% to broiler diets had no significant adverse effects on performance parameters, while the enzyme had a significant effect on BWG, carcass weight and yield of abdominal fat. The group fed 16% DTP with MZ recorded the significant ($P \leq 0.05$) highest final body weight and best FCR among all groups. In this consentient, [3] concluded that tomato seeds up to

15% could safely replace corn and SBM at starter diet of chicks provided that ME and digestible amino acid were adjusted which was applied in this study using the isocaloric and isonitrogenous diet. Because of the interaction of DTP and MZ was significant (P≤ 0.05) for final body weight and feed intake. It could be suggested that the MZ supplementation contains cellulase, xylanase, and glucanase assembled with higher level of DTP inclusion (16%) incorporated in isonitrogenous isocaloric diets had helped to hydrolyze the high amount of fiber [9] which represent a blockage for digestive enzymes to reach nutrients, reduce digestion, absorption and consequently gain [10]. [12] found that multi-enzyme supplementation and tomato pomace had a cumulative significant effect on performance .

The results of immune parameters indicated that regardless of the DTP inclusion level, no effect on both humeral and cell-mediated immunity had been detected. It is well known that immune system of the body is essentially responsible for fighting defense against different infectious and non- infectious agents. The results of both HI against NDV represent humeral immune system parameter and phagocytic activity and index as the parameters of cell-mediated immunity were significantly (P≤ 0.05) affected by multi-enzyme supplementation rather than DTP inclusion. These results come in harmony with the bird's performance response demonstrated significant (P≤ 0.05) better body weight and FCR in the groups fed higher levels of DTP with MZ which could be partially elicited by the CF or NSP present in the DTP analysis (Table 1). As the result of the shorter digestive tract and the digesta passage time, poultry is ineffectual in utilizing fiber [27].The supplementation of the MZ helped to dissolve and hydrolyzing the resisting cell wall enable the endogenous digestive enzyme to perform more efficiently decreasing the maintenance requirement [28] and rendering more nutrients for growth and immunity. The improvement of overall performance and immunity is the outcome of many factors, with most important one is the proper nutrition which modulates performance and immune status of the animal. Scarce studies have been conducted to correlate the multi-enzyme supplementation to DTP containing diets to bird's immunity. However, [29] concluded that multi-enzyme supplementation improved BW, FCR, phagocytic activity and index, and immune organs relative weights when compared with chick group fed palm kernel cake without enzyme supplementation and the efficacy of enzyme was more pronounced with increasing PKC inclusion levels in broiler diets .

The higher abdominal fat % associated with a high inclusion rate of DTP with no exogenous enzyme might be attributed to the binding potentiality of the high CF content of DTP that limits many nutrients to be available for the bird's growth especially energy and consequently pushed them to consume more feed and to retain more fat (Table 4). [25] reported reduced protein digestibility and nitrogen retention of broiler chickens fed 15% DTP. Moreover, the significant (P≤ 0.05) increase of the giblets % in the DTP- fed groups without MZ might be related to the increase in the gizzard weight, as the high level of CF in the DTP enhances automatic grinding capacity of the gizzard's muscles [26]. Nevertheless, the combined effect of MZ with DTP feeding significantly (P≤ 0.05) decreased both abdominal fat and giblets % confirming the role of MZ in dissolving the difficult cell wall of DTP renders more nutrients to be available for utilization as supported with growth performance results (Table 3). These results come in agreement with [24] who reported that the use of DTP at all levels (50, 100 and 150 g kg-1) with enzyme supplementation decreased abdominal fat of broilers.

From the results of the economic study (Table6), one can clearly observe that the group fed 16% DTP with MZ surpassed all groups in the net revenue as well as the % of economical efficiency. These result supported by the performance results strongly emphasized the practical inclusion of higher levels of DTP in balanced broilers diet on condition of suitable multi-enzyme supplementation to promote efficient and economical broilers production .

5. CONCLUSIONS

DTP is strongly recommended to be incorporated in broiler diets at higher levels up to 16% when suitable multi-enzyme is also included not only to reduce the cost of the diet but also to maintain good performance, immune status and carcass traits.

T	T	Carcass trait parameters		
DTP%	**MZ**	**Dressing %**	**Abdominal Fat %**	**Giblets %**
0	0	73.2	2.34	5.48
	+	73.8	2.18	5.33
8	0	73.7	2.65	5.77
	+	74.4	2.10	5.24
16	0	72.2	2.88	5.96
	+	74.5	1.87	5.48
Main Effects	SEM (n=3)[a]	0.9	0.07	0.11
	DTP%			
	0	74	2.3[b]	5.4[b]
	8	74	2.4[a]	5.5[b]
	16	73	2.4[a]	5.7[a]
	MZ			
	0	73	2.6[a]	5.7[a]
	+	74	2.1[b]	5.4[b]
Probabilities	DTP%	NS	*	*
	MZ	NS	*	*
	DTP*MZ	NS	*	NS

[a]Pooled standard error of the mean(n=number per treatment)

Each value represents the mean of 3 replicates (9 birds / replicate).

NS, non-significant.

*P≤ 0.05

Table 4. Effect of dietary supplementation of DTP and multi- enzymes on carcass traits (% live weight) of broilers

Meat	**Evaluation scheme**			**Experimental groups**					
				Groups					
				0DP/MZ	**0DP/+MZ**	**8%DTP/0MZ**	**8%DTP/+MZ**	**16%DTP/0MZ**	**16%DTP/+MZ**
Row	**Color**[1]	**Breast**	L	0	0	0	0	0	0
			S	9	9	9	9	9	8
			D	0	0	0	0	0	0
		Thigh	L	0	0	0	0	0	0
			S	9	9	9	9	8	8
			D	0	0	0	0	1	1
Cooked	**Odor**[2]		N	9	9	9	9	9	9
			U	-	-	-	-	-	-
	Flavor[3]		A	9	9	9	9	9	8
			B	-	-	-	-	-	1
			C	-	-	-	-	-	-
	Tenderness[3]		A	9	9	9	9	8	8
			B	-	-	-	-	-	1
			C	-	-	-	-	-	-

[1]Color: L=lighter; S=similar; D=darker compared to normal commercially available broiler meat.

[2]Odor: N=normal, U=abnormal.

[3]Flavor and tenderness assessment: A=very good, B=good, C=fairly acceptable.

Table 5. Organoleptic test results for broilers carcass (n=9) subjected to different dietary treatments.

Dietary treatment	Control	Control+MZ	8% DTP	8% DTP+MZ	16%DTP	16%DTP+MZ
Total fixed costs (LE)/ bird)	8	8	8	8	8	8
Total feed intake (g)/ bird	3622.5	4416.6	3908.6	4003.2	3522.2	4332.5
Basal feed price/kg[1]	5.0	5.0	5.3	5.3	4.9	4.9
Total feed cost/bird	18.1	22.1	20.72	21.22	17.3	21.23
Total cost/ bird	26.1	30.1	28.7	29.22	25.3	29.23
Average final body weight	2122.5	2624.4	2353.6	2467.3	2008.1	2715.5
Total income[2]**/bird**	61.6	76.1	68.3	71.6	58.23	78.74
Net revenue (LE)/ bird	43.5	46.0	47.6	50.4	40.93	57.51
Economic efficiency[3]**(%)**	240.3	208.1	229.8	237.5	161.8	270.8
% change of economical efficiency[4]	100	86.6	95.6	98.8	67.3	112.7

[1]The basal feed price =average price of the starter + finisher & DTP cost=180 LE/ton

[2]Total income= average final body weight× price of one kilogram of live chicken (29L.E)

[3]Economic efficiency= (net revenue (total income –feed cost) / feed cost) ×100

[4]% change of economical efficiency in comparison to the control non-supplemented group

Table 6. Economic efficiency study of the experimental trial

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