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Original Article

Effects of Dietary Dried Tomato Pomace with an Exogenous Enzyme Supplementation on Growth Performance, Meat Oxidative Stability and Nutrient Digestibility of Broiler Chickens

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Abstract

Two experiments were conducted to evaluate the effects of feeding diets containing different inclusion rates of dried tomato pomace (DTP) with or without enzyme supplementation on performance, meat quality and nutrient digestibility in broiler chicks. In experiment 1, four hundred and twenty 1 day-old broiler chicks were distributed in seven treatments and four replicates per each treatment. The dietary treatments were a control diet and three levels (50, 100 and 150 g kg^{-1}) of DTP with or without enzyme supplementation. Growth performance was recorded from 1 to 42 days of age and at the end of the experiment 1 (d 42) carcass analysis was done. The thigh meat samples were used and stored at 1, 7 and 30 days after slaughter to thiobarbituric acid reactive substances (TBARS) measurement as an indicator for meat quality. In experiment 2, nutrient digestibility and metabolisable and ileal digestible energy value were measured. Results of experiment 1 showed that dietary treatments influenced both gain, feed intake and feed conversion ratio of broilers ($P<0.05$). Carcass characteristics, but not for breast percentage, were affected by dietary treatments ($P<0.05$). The internal organs of broilers except for gizzard, were influenced by use of experimental diets ($P<0.05$). Results of oxidative stability showed that TBARS was affected by dietary treatments on 30 days after storage ($P<0.05$). However, TBARS was not changed by DTP dietary treatments on 1 and 7 days after storage. In experiment 2, nutrient digestibility decreased by increasing the levels of DTP in diets without enzyme supplementation ($P<0.05$). However, the differences between control group and diets with 5% DTP with enzyme supplementation were not significant, generally. In conclusion, use of 50 g kg^{-1} DTP with enzyme supplementation improved feed conversion ratio and crude protein digestibility in broilers.

Key words: By-product, antioxidant activity, broiler

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Abbreviation

DTP	Dried Tomato Pomace
TBARS	Thiobarbituric Acid Reactive Substances
TCA	Trichloroacetic Acid
GE	Gross Energy
IDE	Ileal Digestible Energy
NRC	National Research Council

Introduction

Tomato (*Lycopersicun esculentum*) is one of the most widely cultivated vegetable crops in Iran (Rezaeipour *et al.*, 2008). Tomato pomace is a byproduct obtains from the processing of tomatoes for concentrated paste, juice, sauce and ketchup and contains skin and seeds. Tomato pomace is a fibrous material and small proportion is dried and use as an animal feed (Haddadin *et al*., 2001). The high fiber content of dried tomato pomace indicates that it can be use in poultry diets at low inclusion rates as an alternative to cereal byproducts (Dotas *et al*., 1999). researchers are constantly searching for ways to improve the worldwide use of tomato residues by including them in poultry feed (Assi & King, 2007; Squires *et al*., 1992).

One approach to increase the rate of these ingredients in poultry diets is possible by hydrolyzing the crude fiber into digestible saccharides (Haddadin *et al*., 2001). Grinding and alkali treatment have been used in various countries to improve the nutritive value of fibrous diets (Abiola *et al*., 2002; Squires *et al*., 1992). Sobamiwa & Longe (1994) reported that it may be treated cocoa husk meal by alkali and included in broiler diets. Use of alkali-treated tomato pomace in broiler diets was studied by some authors (Squires *et al*., 1992; Al-Betawi, 2005) who reported that alkali treated led to increase the tomato pomace inclusion rate in broiler diets. Supplementing of dietary enzymes to high crude fiber diets like to barley–soybean meal diets is a common practice, but a few reports are concerned with diets supplemented with tomato pomace.

Nutritional evaluation of dried tomato seed, but not tomato pomace, was investigated by Persia *et al*. (2003). However, information about nutrient digestibility of tomato pomace is limited.

Lipid oxidation is a major cause of quality deterioration in broiler meat (Gray *et al*., 1996). Because of that poultry meat is relatively rich in polyunsaturated fatty acids (Goni *et al*., 2007). Synthetic antioxidant have been used to control lipid oxidation in stored meat, but concern about their use had created a need research for alternative antioxidant, particularly from natural sources (Goni *et al*., 2007). Beneficial effects of some micronutrients known as natural antioxidant such as vitamin E, ascorbic acid and lycopene have been reported. Dried tomato pomace (DTP) is an excellent source of α-Tocopherol (vitamin E) and lycopene (Sahin *et al*., 2008). So, it may be a new source of antioxidant to prevent lipid oxidation in broiler meat.

So, the aim of this study was to determine the effects of DTP in diets with or without enzyme supplementation on growth performance, carcass characteristics, meat quality and nutrient digestibility in broiler chicks.

Materials and Methods

Experiment 1

Tomato pomace used in this study was provided from the agricultural marketing and processed in a commercial company (Caspian Animal Feed Company, private limited, Karaj, Iran). The raw tomato pomace (wet materials) was dried by air warm at 52 °C for 35 minutes and then ground to powder with a hammer mill to provide dried tomato pomace (DTP).

Duplicate samples of DTP were analyzed for chemical composition in our animal nutrition laboratory. Briefly, the samples were oven dried and ground. Chemical composition of samples for dry matter, crude protein, crude fiber, ether extract, calcium, total phosphorous, ash and sodium were determined by association of official analytical chemists methods (AOAC, 2000). Gross energy was determined using a PARR-1261 adiabatic bomb calorimeter. Lycopene and α-Tocopherol content of DTP were measured by high performance liquid chromatography method (AOAC, 2000) and Craft *et al*. (1993), respectively. The chemical composition of dried tomato pomace is shown in Table 1.

Four hundred and twenty 1 day-old Ross 308 broiler chicks (Mixed sex) were obtained from a local hatchery. Birds were weighed and randomly assigned to 28 straw/wood shavings mix floor pens with 15 birds per pen. The chicks were raised on floor pens for 42d and had free access to feed and water during the whole period of experiment. The ambient temperature was maintained at 32 °C for the first 3d and then gradually decreased until 24 °C was reached by 21d. Experimental procedures were approved by Gorgan University of agricultural sciences and natural resources.

Birds were fed with one of seven dietary treatments consisted of a control corn-soybean meal diet and six diets incorporated with 50, 100 and 150 g kg^{-1} of DTP with or without enzyme supplementation. The enzyme supplemented diets were prepared by adding 5g/kg of Rovabio multi enzyme which contained 2200 U/g Xylanase, 500 U/g β-glucanase, 2200 U/g Cellulase, 1000 U/g pectinase and 15 U/g protease. Dietary treatments were formulated with equal nutrients to energy ratio to meet or exceed the minimum NRC (1994) requirements for starter (1-21d) and grower (22-42d) periods in broiler chicks. In order to diets formulation crude protein concentration in corn, soybean meal and DTP were measured by kjehldal method and AMEn value for DTP was assumed 1747 kcal kg^{-1} based on our previous study (Rezaeipour *et al*., 2008). Compositions of the experimental diets are shown in Table 2.

All birds were group weighed by pen after overnight fasting at 21 and 42d. Feed intake on group basis was measured at the same time intervals. Feed conversion ratio for each pen was calculated by dividing feed intake to body weight gain. Mortality was checked daily and weighed for adjusting feed conversion ratio.

At the end of the experiment 1 (on day 42), after overnight fasting , two birds from each pen with a body weight close to pen mean were selected and killed by cervical dislocation. Viscera were manually removed and carcass characteristics (carcass yield, breast, thigh and abdominal fat) determined as described by Perrault and Leeson (1992). Then, empty weight of total digestive tract, caeca, gizzard, liver (without gallbladder) and pancreas were measured. All carcass data are presented based on percent of live weight of each bird.

At the end of the experiment 1 and after carcass analysis, the thigh meat of each bird were removed and sampled for meat lipid oxidation study (TBARS). The extent of lipid oxidation was determined by measuring the Thiobarbituric Acid Reactive Substances (TBARS) at 1, 7 days (after refrigerated storage) and 30 days (after freezer storage) and was expressed as gram of malonaldehyde per kilogram of thigh meat using the procedure described by Strange *et al*. (1977). Twenty grams of bone meat were blended with 50 ml of cold 20% trichloroacetic acid (TCA) for 2 minutes. The blender contents were rised with 50 ml of water, mixed together, and filtered through a Whatman#1. This filtrate is termed the TCA extract and is used in the TBA assessment. A 5 ml of the TCA extract was mixed with 5 ml of 0.01 M 2-thiobarbituric acid. This solution kept for 14 h at room temperature. Absorbance at 532 nm is reported as TBARS.

Experiment 2

Eighty and four 1 day-old Ross 308 male broiler chicks were raised on floor pens in an environmentally controlled room from days 1 to 13. On day 14, the birds were weighted individually and transferred to experimental cages. Twelve birds were allocated to three cages per each treatment. The dietary treatments were the diets in experiment 1, which supplemented with 3 g /kg chromic oxide, as an indigestible marker. Feed and water were available *ad libitum* in whole period of experiment. There was no mortality during the trial. From days 18 to 21, and 39 to 42, excreta samples were collected for each cage. Excreta collected daily at 9.00 h, dried at 60 °C for 48h, ground and stored in airtight plastic containers at -4°C for subsequent analysis. On days 21 and 42, two birds per each cage were killed by cervical dislocation and the small intestine was immediately removed and contents of 15 cm terminate of the lower of ileum were collected. Ileal digesta of birds within a pen were pooled, resulting in three composite samples per each treatment. Samples were oven dried and then ground and stored in -4 °C for chemical analysis. Chromic oxide concentration was measured in all samples by method described by Fenton and Fenton (1979). The gross energy (GE) of excreta, ileal digesta and diets were measured by PARR-1261 adiabatic bomb calorimeter to calculating the AME and AMEn for excreta samples and ileal digestible energy (IDE) for ileal digesta samples. The dry matter, nitrogen content and ether extract of ileal digesta and diets were measured according to AOAC (2000) methods. The crude protein content was calculated by 6.25 × N content of samples.

The AME and IDE content of diets were calculated using the following formulas:

$$AME\ (Mj\ kg^{-1}) = GE_{diet} - [GE_{excreta} \times (Marker_{diet}/Marker_{excreta})]$$

$$IDE\ (Mj\ kg^{-1}) = GE_{diet} - [GE_{ileal\ digesta} \times (Marker_{diet}/Marker_{ileal\ digesta})]$$

Where: GE=Gross Energy (Mj kg^{-1}) of samples and Marker=concentration of chromic oxide in samples.

The correction of AME to zero nitrogen retention was done for determination of AMEn in excreta samples (Hill & Anderson, 1958).

Apparent digestibility of nutrients was calculated as follows:

$$Digestibility\ (\%) = 100 - [100 \times (Marker_{diet}/Marker_{ileal\ digesta}) \times (N_{ileal\ digesta}/N_{diet})]$$

Where: N=concentration of nutrient.

The experiment design was a completely randomized design with seven treatments. Statistical analysis was performed using the General Linear Models procedure of SAS (2001). Probability values <0.05 were taken to indicate statistical significance using Duncan multiple range test.

Results and Discussion

Experiment 1

The chemical composition of DTP is presented in Table 1. Results of Table 1 showed that DTP contained a high total fiber. However, these materials are a good source of vitamin E and lycopene.

The results of growth performance are shown in Table 3. All growth performance traits were affected by dietary treatments. The results indicated that use of DTP at 50 g kg^{-1} with or without enzyme supplementation increased broilers gain as similar to control group. The highest broiler feed intake was belonged to control group and treatment with 150 g kg^{-1} DTP with enzyme supplementation. Feed conversion ratio was improved in diets with 50 g kg^{-1} DTP with enzyme supplementation than the other treatments.

Table 1: Chemical composition of dried tomato pomace

Components	(%)
Dry Matter	92.07
Crude Protein	18.15
Ether Extract	6.60
Ash	6.62
Crude fiber	22.72
Ca	0.59
Total P	0.78
Na	0.20
GE (kcal kg^{-1})	3047
AMEn (kcal kg^{-1})*	1747
mg g^{-1}	
α-tocopherol	0.039
Lycopene	0.527

*AMEn value was determined in our previous study (Rezaeipour et al., 2008)

The carcass compositions of broilers are presented in Table 4. There was no effect of dietary treatments on breast percentage, but the effects were differed for carcass, thigh and abdominal fat percentage. Carcass and thigh percentage of broilers fed diets with 50 g kg^{-1} DTP and enzyme supplemented were better than the other treatments. The results of Table 4 show that use of DTP at all levels (50, 100 and 150 g kg^{-1}) with enzyme supplementation decreased abdominal fat of broilers. The results of digestive organs of broilers fed dietary treatments are presented in Table 5. All digestive organs, except for gizzard, were affected by dietary treatments. Digestive organs weights were increased with the increase of DTP inclusion rate in the diets.

The results of the meat quality analysis are presented in Table 6. Results indicated that the extent of lipid oxidation (TBA number) in thigh meat after 1 and 7 d of refrigerated storage was not differed between all treatments. However, malonaldehyde concentration was different after 30 d of freezer storage. Utilization of DTP in diets decreased TBA number of thigh meat 30 days after storage.

Experiment 2

The effects of dietary tomato pomace on apparent nutrient digestibility, AME, AMEn and ileal digestible energy (IDE) at d 21 and 42 with excreta and ileal digesta sampling are presented in Tables 7 and 8. Results indicated that AME, AMEn and IDE of diets decreased with increase of DTP inclusion rate of DTP at both 21 and 42 d. Results of Table 7 show that effects of dietary treatments on ether extract digestibility were not different. However, crude protein and dry matter digestibility were affected by treatments. Results of Table 8 indicated that all of digestibility coefficients were affected by dietary treatments. The highest crude protein digestibility coefficients observed in broilers fed diets with 50 g kg^{-1} DTP and enzyme supplementation.

Table 2: Ingredients and chemical composition of experimental diets (g kg^{-1})

	Starter				Grower			
Feed ingredients	**Control**	**50**	**100**	**150**	**Control**	**50**	**100**	**150**
Corn grain	581.7	543.6	505.5	467.4	641.6	603.1	564.6	526.1
Soybean meal	365.8	347.7	329.6	311.3	307.3	291.8	273.3	254.8
Dried tomato pomace	-	50	100	150	-	50	100	150
Soybean oil	10.7	17.0	23.3	29.7	14.1	20.1	26.2	32.2
Limestone	12.5	12.5	12.5	12.5	13.4	13.4	13.4	13.4
Di-calcium phosphate	13.8	13.8	13.8	13.8	10.1	10.1	10.1	10.1
Salt	4.2	3.9	3.6	3.4	3.1	2.9	2.6	2.4
Min-Vit premix*	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Choline	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
DL-Met	1.3	1.5	1.7	1.9	0.4	0.6	0.8	1.0
Chemical analysis								
AME_n (kcal kg^{-1})	2870	2845	2820	2795	2970	2945	2920	2895
Crude protein	206.0	204.5	202.7	201.0	185.6	184.0	182.5	181.0
Calcium	9.0	9.2	9.3	9.7	8.4	8.6	8.8	9.0
Available P	4.0	4.0	4.0	4.0	3.2	3.2	3.2	3.2
Lysine	11.5	11.6	11.9	12.0	10.0	10.3	10.5	10.7
Methionine + Cystine	8.1	8.0	7.9	7.9	6.7	6.6	6.6	6.5

*Each kg of vitamin supplement containing: vit A: 360000 IU, Vit D3: 800000 IU, Vit E: 7200 IU, Vit K3: 800 mg, Vit B1: 720 mg, Vit B2: 2640 mg, Vit B3: 4000 mg, Niacin: 12000 mg, Vit B6: 1200 mg, Folic acid: 400 mg, Vit B12: 6 mg, Biotin: 40 mg and choline chloride: 100000 mg. Each kg of mineral supplement containing: Manganese: 39680 mg, Zinc: 33880 mg, Copper: 4000 mg, Iodine: 400 mg and Selenium: 80 mg.

Table 3: Body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) of broiler chicks fed dietary treatments

Treatments		Performance		
DTP*	**Enzyme**	BWG (g/bird/day)	FI (g/bird/day)	FCR
Control	-	48.46^{a}	93.67^{a}	1.92^{d}
50	-	45.64^{abc}	91.21^{ab}	2.01^{cd}
100	-	43.00^{cd}	88.34^{ab}	2.05^{bc}
150	-	39.64^{d}	89.87^{ab}	2.26^{a}
50	+	46.96^{ab}	86.87^{ab}	1.85^{e}
100	+	42.20^{cd}	83.63^{b}	1.98^{cd}
150	+	43.16^{bcd}	92.00^{ab}	2.13^{b}
SEM		1.24	2.76	0.03

[a-d]Means without a common superscripts in per column are significantly different (P<0.05).
*Dried tomato pomace

Table 4: Carcass characteristics (percent of live weight) of broilers fed dietary treatments

Treatments		Carcass	Breast	Thigh	Abdominal fat
DTP[*]	Enzyme			(%)	
Control	-	60.59[ab]	21.37	19.36[ab]	1.89[a]
50	-	60.87[ab]	21.92	19.12[ab]	1.36[b]
100	-	60.43[ab]	20.87	20.37[a]	1.87[a]
150	-	61.13[ab]	21.52	19.84[ab]	2.17[a]
50	+	62.98[a]	21.77	19.37[ab]	1.05[b]
100	+	58.65[b]	20.44	18.28[ab]	1.25[b]
150	+	57.72[b]	20.39	17.75[b]	0.97[b]
SEM		1.15	0.68	0.73	0.12

[a-b]Means without a common superscripts in per column are significantly different (P<0.05).
[*]Dried tomato pomace

Table 5: Digestive organs percentage (per live weight) of broilers fed dietary treatments

Treatments		TDT[†]	Gizzard	Caeca	Liver	Pancreas
DTP[*]	Enzyme	(%)				
Control	-	8.52[c]	1.76	0.28[b]	2.52[b]	0.25[ab]
50	-	8.71[bc]	1.87	0.33[ab]	2.78[ab]	0.28[a]
100	-	9.05[bc]	1.72	0.33[ab]	2.69[ab]	0.22[b]
150	-	9.32[ab]	1.87	0.38[a]	2.84[ab]	0.27[a]
50	+	8.59[c]	1.81	0.33[ab]	2.73[ab]	0.24[ab]
100	+	8.84[bc]	1.91	0.29[b]	2.69[ab]	0.25[ab]
150	+	9.75[a]	1.97	0.37[a]	3.04[a]	0.26[ab]
SEM		0.21	0.10	0.018	0.12	0.013

[a-c]Means without a common superscripts in per column are significantly different (P<0.05).
[*]Dried tomato pomace
[†]Total digestive tract

The most authors indicated that the high fiber content of tomato pomace is a major problem of its feeding in poultry nutrition (Persia *et al*., 2003; Squires *et al*., 1992). The composition of tomato pomace varies according to agricultural and processing practices, the degree of drying and moisture removal (King & Zeidler, 2004). Marcos *et al*. (2006) reported that, the chemical components of tomato pulp are included: 19.27% crude protein, 5.85% crude fat, 7.55% pectin (galacturonic acid) and 59% neutral detergent fiber.

It seems that the birds fed on high levels of dietary tomato pomace do not able to receive their energy requirements, and so the gain was less. The higher crude fiber content of dietary tomato pomace had a restriction effect on the available energy content of the diets (Squires *et al*., 1992). These results are similar to the findings of Kavitha *et al*. (2003) who reported that gain showed a decreasing trend with an increase in tomato pomace level in chickens. Sahin *et al*. (2008) indicated that 2.5 and 5% inclusion rate of tomato powder improved the gain and feed conversion ratio in Japanese quails. Rahmatnejad *et al*. (2011) suggested that DTP can be included in diets for broiler chickens up to 8% without any adverse effect on performance.

Enzyme supplementation in diets with DTP improved growth performance of broilers. It is clear that tomato pomace is a fibrous matter, and chickens need to exogenous enzymes such as xylanase, glucanase and cellulase to break these polysaccharides. Cellulase is widely used for supplementing diets rich in fibers fed to mono gastric animals, particularly poultry and the various impacts of enzyme supplementation are usually reflected by a considerable improvement on growth and feed conversion ratio of poultry (Ponte *et al*., 2004).

Digestive organs weights were linearly increased with the increasing dietary tomato pomace rate in the diets. These findings are similar to results of Tabook *et al*. (2006) who reported that with increase of date fiber in the diets, the weight of total digestive tract, small intestine, caecum and pancreas of broilers increased. It is well documented that the birds digestive tract change to the presence fibrous diets in terms of length, weight, absorptive area and rate of turnover of entrocytes (Savory & Knox, 1991). Abiola *et al*. (2002) indicated that birds on fibrous diets are known to exhibit greater mechanical grinding, and this usually stimulates the muscular walls of gizzard and increase the intestinal weight. Subsequently, Hetland *et al*. (2004) reported that use of fibrous diets increased the gut volume in broilers. The increase of total digestive tract with increase of tomato pomace inclusion rate in present study may be due to the increase in digestive tract length or its absorptive area.

Malonaldehyde, a byproduct of lipid deterioration, was extracted from meat and during oxidation process; and thiobarbituric acid (TBA) was reacted with malonaldehyde (King & Zeidler, 2004). With increase of DTP in the diets the TBA number was decreased. Smet *et al*. (2005) reported that tomato pomace as an antioxidant improves the broiler meat after 7 and 10 days of refrigerated storage. Tomato pomace is a good source of Vitamin E and lycopene (Table 1). Tomato also contains other carotenoids, including phytoene, phytofluene, and the provitamin A (Rao & Agrawal, 1999; Assi & King, 2007). Lycopene is a major carotenoid present in the tomato pomace and highly potent antioxidant that provides protection against cellular damage (Sahin *et al*., 2008). The α-tocopherol has been added to poultry feed as a potential antioxidant to retard lipid oxidation in meat (Assi & King, 2007). High concentrations of vitamin E have beneficial effects, such as prolonged shelf life, because oxidative deterioration is delayed by the high tocopherol content of muscles and fat tissues (Ruiz *et al*., 2001). King & Zeidler (2004) indicated that vitamin E content of tomato pomace was excellent and protect the broiler meat from lipid deterioration. So, dietary tomato pomace reduced the negative effects of lipid oxidation in broiler meat after storage, and improved the meat quality.

Apparent nutrient digestibility, AME, AMEn and ilea digestible energy (IDE) values by chicks fed the control and low proportion of DTP (50 g kg^{-1}) diets were superior compared with chicks fed diets with high levels of DTP. Study with the broilers support the view that chickens are less able to degrade fiber and there is a three-fold decrease in nutrient digestibility in broilers between a high-fiber and a low-fiber diet (Jorgensen *et al*., 1996). Reasons for the effects of fiber on protein digestibility are not clear, but total fiber in the diets and protein digestibility are negatively related (Newkirk *et al*., 1997). Fibers, mainly the insoluble, decrease apparent protein digestibility by increasing fecal excretion of cell wall bound protein; also, fermentable fibers increase fecal protein excretion with stimulation of bacterial nitrogen assimilation (Choct *et al*., 1996). Kavitha *et al*. (2003) indicated that increasing of tomato pulp levels in diets of broilers led to decrease of nitrogen utilization. Squires *et al*. (1992) reported that nitrogen retention was decreased in broilers fed on 20% dried tomato cannery waste in comparison to 10%. So, it is suggested that use of high fiber diets (such as 15% DTP) can reduce the digestibility of protein in broiler chickens.

The influence of dietary fiber components on lipid metabolism in animals has been studied. There is a negatively interaction between fiber and fat digestibility in broilers (Smith, 1996). The most important factor in the tomato pulp is their ability to bind with bile salts and acids, restricting the formation of micelles and finally decreasing of lipid digestibility (Pavel, 1999). It is appear that binding to fibrous matter increases excretion of bile acids and reduce their reabsorption into the liver, resulting by a feedback mechanism. However, in contrast to this study, Kavitha *et al*. (2003) reported that the fat digestibility is improved by increasing tomato pulp in diets. Reduce of AME and AMEn by increasing inclusion rate of DTP in diets may be due to decreasing of nutrient digestibility.

Numerous studies of exogenous enzymes supplementation in broiler diets have been conducted and improvement nutrient digestibility has been well documented. Zhao *et al*. (2007) indicated that use of enzymes in broiler diets increased the nutrient digestibility. They also suggested that compared to the high-AME diet, enzyme supplementation to low-AME feed ingredients would be more efficient.

Table 6: TBA-Reactive Substances (TBARS) of thigh muscle (g kg^{-1} malonaldehyde) of broilers fed dietary treatments

Treatments		Days after storage		
DTP[*]	Enzyme	1	7	30
Control	-	0.099	0.38	1.20[a]
50	-	0.090	0.42	1.19[ab]
100	-	0.078	0.35	0.90[bcd]
150	-	0.091	0.34	0.80[d]
50	+	0.097	0.42	1.13[ab]
100	+	0.087	0.35	1.18[a]
150	+	0.083	0.37	0.86[cd]
SEM		0.01	0.03	0.08

[a-d]Means without a common superscripts in per column are significantly different ($P<0.05$).
[*]Dried tomato pomace

Table 7: Effects of dietary treatments on apparent nutrient digestibility (%), metabolisable energy (Mj kg^{-1}) and ileal digestible energy (Mj kg^{-1}) of broilers at d 21

Treatments		Excreta		Ileal digesta			
DTP[*]	Enzyme	AME	AMEn	DM	CP	EE	IDE[†]
Control	-	11.89[a]	11.79[a]	71.71[a]	71.68[cd]	69.33	11.83[a]
50	-	11.86[ab]	11.75[a]	71.55[ab]	71.44[cd]	68.77	11.76[ab]
100	-	11.82[b]	11.69[a]	71.81[a]	71.17[cd]	68.72	11.70[abc]
150	-	11.66[c]	11.56[b]	69.55[b]	70.26[d]	65.71	11.59[c]
50	+	11.89[a]	11.79[a]	72.53[a]	74.15[a]	69.25	11.77[a]
100	+	11.81[b]	11.76[a]	72.33[a]	73.72[ab]	68.79	11.71[abc]
150	+	11.66[c]	11.55[b]	71.24[ab]	72.19[bc]	66.25	11.63[bc]
SEM		0.021	0.031	0.78	0.54	1.14	0.040

[a-d]Means without a common superscripts in per column are significantly different ($P<0.05$).
[*]Dried tomato pomace
[†] Ileal digestible energy

Table 8: Effects of dietary treatments on apparent nutrient digestibility (%), metabolisable energy (Mj kg^{-1}) and ileal digestible energy (Mj kg^{-1}) of broilers at d 42

Treatments		Excreta		Ileal digesta			
DTP[*]	Enzyme	AME	AMEn	DM	CP	EE	IDE[†]
Control	-	12.41[a]	12.25[a]	71.56[ab]	73.24[c]	70.97[ab]	12.35[a]
50	-	12.24[bc]	12.17[abc]	70.81[b]	73.71[bc]	70.20[abc]	12.19[b]
100	-	12.16[d]	12.06[cd]	71.49[ab]	72.15[c]	70.52[ab]	12.11[c]
150	-	12.05[e]	11.89[e]	69.96[b]	71.32[c]	68.13[c]	11.93[d]
50	+	12.30[b]	12.23[ab]	73.55[a]	78.75[a]	71.59[a]	12.24[b]
100	+	12.18[cd]	12.10[bcd]	70.94[b]	76.38[ab]	70.89[ab]	12.12[c]
150	+	12.07[e]	11.99[de]	70.72[b]	72.25[c]	69.24[bc]	11.98[d]
SEM		0.020	0.043	0.67	0.89	0.68	0.023

[a-e]Means without a common superscripts in per column are significantly different ($P<0.05$).
[*]Dried tomato pomace
[†] Ileal digestible energy

Conclusion

In conclusion, results of experiment one suggested that DTP could be included up to 50 g kg^{-1} in broiler diets. However, enzyme addition improved the growth performance and carcass characteristics of broilers fed diets containing DTP. Use of DTP improved meat quality 30 days after freeze storage. In experiment 2, enzyme supplementation improved the nutrient digestibility of diet supplemented with DTP.

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